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EAST LANSING

THE QUARTERLY BULLETIN

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AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
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NEW PRACTICES FOR INCREASING THE FRUIT CROP OF GREENHOUSE-GROWN TOMATOES

By S. H. WITTWER and F. G. TEUBNER

DEPARTMENT OF HORTICULTURE

DURING THE PAST THREE YEARS, efforts to control flower formation and fruiting in the greenhouse-grown tomato have led to some phenomenal results and yield increases (Fig. 1). The research has attracted the constant attention and interest of many commercial growers. Some

Fig. 1. Commercial growers have increased their yields with clusters like this by following the recommendations described in this article. Individual clusters of 15 to 20 fruit and weighing up to 5 pounds are possible.

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of the findings have been applied to crops in Michigan, Ohio, and Indiana. This summary of results and recommendations has been prepared to give the industry a look at the research findings.

Flowers of the first cluster are formed within the 2- to 3-week period immediately following the unfolding or expansion of the seed leaves (cotyledons) of the tomato plant. This is the period when flower numbers in the first cluster are directly affected by temperature, light, nutrition, chemicals and perhaps still other factors.

The number of leaves that occur before the cluster is initiated is determined early, and may also be influenced by several of the above factors. This is usually 4 to 6 weeks before the first flowers open. Greenhouse tomato varieties with high fruit quality seldom produce enough early flowers for top yields. Thus, fruit production is often limited by flower number.

CHILLING THE PLANTS

"Chilling" tomato plants for 2 to 3 weeks at 50 to 55° F. (night temperature) beginning after the seed leaves (cotyledons) unfold will often double the number of early flowers and cause the first cluster to appear after fewer leaves, as contrasted to plants grown continuously at 60 to 70° F. (Fig. 2). There are at least four noticeable differences in "chilled" tomato plants:

(1) There are one to two fewer leaves before the first cluster. Consequently, plants flower nearer the ground level.

TABLE 1—The flowering response of five greenhouse forcing type tomato varieties to low temperatures (50-55°F.) following expansion of the seed leaves and to foliage sprays of 200 p.p.m. of N-m-tolylphthalamic acid applied at the third and sixth leaf stages

Variety	Nodes to 1st cluster		Flowers in 1st cluster				Flowers in 2nd cluster	
	Continuous high (65-70°F.)	3 weeks of low (50-55°F.)	Continuous high (65-70°F.)	3 weeks of low (50-55°F.)	No chemical	Chemical	No chemical	Chemical
Spartan Hybrid.....	8.1	6.8	9.8	24.4	9.0	25.2	8.1	12.0
Michigan-Ohio Hybrid..	7.9	6.8	13.7	16.6	8.1	22.2	8.4	13.3
Michigan State Forcing.	8.1	7.1	11.1	13.9	8.6	16.4	7.4	9.0
Ohio WR3 Pink Globe..	7.8	6.4	9.9	12.8	5.5	17.2	5.9	7.9
Waltham Forcing.....	7.5	6.6	15.9	21.9	9.9	27.9	8.2	21.2
Average (all varieties)..	7.9	6.8	12.0	17.9	8.2	21.8	7.6	12.7

(2) The plants are blockier, sturdier, have thicker stems; rapid recovery following transplanting is favored.

(3) Flower numbers in the first and often in the second cluster may be doubled. Fifteen to 25 flowers (Table 1) on branched (compound) clusters are common.

(4) Fruit clusters are correspondingly larger and early yields are increased (Tables 2 and 3).

Fig. 2. "Chilling" tomato plants for 2 to 3 weeks at 50 to 55°F. (night temperature) beginning after the seed leaves (cotyledons) unfold will often double the number of early flowers and cause the first cluster to appear after fewer leaves (plant at right), as contrasted to plants grown continuously at 60 to 70°F. (plant at left).

SPRAYING WITH CHEMICAL

Increased flower number and fruit production may also be attained by spraying plants with N-m-tolylphthalamic acid during the time when flowers are being formed.[1] This chemical increases flower numbers several fold. The resulting compound clusters have two to four times the normal number of flowers and are comprised of several branches (Fig. 3).

[1]The material used in this experiment was U. S. Rubber Company's "Duraset-20W".

TABLE 2—Performance of first flower and fruit cluster of Spartan Hybrid as influenced by temperature and chemical (N-m-tolylphthalamic acid—200 p.p.m.)

Treatment of seedling plants	Flower numbers on first cluster	Pounds of fruit on first cluster
Warm Continuously (65°F.)	8.5	2.5
"Cold Treatment" (50-55°F.)	14.0	3.5
Warm Continuously + Chemical	16.5	3.4
"Cold Treatment" + Chemical	28.2	5.4

Increases in flower numbers may be obtained at any stage during growth on any flower cluster if the chemical is sprayed on the plant at the proper time. Growers of greenhouse tomatoes will be interested in the chemical treatment because it can be used to increase flower and fruit production of any cluster. The "cold treatment" must necessarily be confined to the first clusters.

Fig. 3. Typical compound flower cluster on a plant which received both the cold and chemical treatments (var. Michigan-Ohio Hybrid).

TABLE 3—Yields of marketable tomatoes harvested by clusters from plants exposed to cold (50-55°F.) and warm (65°F.) temperatures during the 2 to 3 weeks immediately following expansion of the seed leaves (var. Spartan Hybrid)

Treatment of seedling	Cluster number					Total pounds for five clusters
	1	*2*	*3*	*4*	*5*	
Warm Continuously (65°F.).....	2.5	2.9	3.0	3.1	3.0	14.5
"Cold Treatment" (50-55°F.)....	3.5	2.8	3.2	3.4	3.0	15.9

Some growers have combined both the cold and the chemical treatments for early clusters on the same plants. The results are roughly additive (Table 2) and flower numbers may be quadrupled. In practice, growers should first become familiar with the effects of the cold and chemical treatments separately and perhaps combine them later.

Fig. 4. This picture shows growth stages of tomato seedlings as related to the effectiveness of "cold treatment" and time of application of N-m-tolylphthalamic acid (200 p.p.m.), to affect the first and second flower clusters. Left to right, front row; plants at 0 (cotyledon expansion), 3, 6, and 9 (two-leaf stage) days later. Back row; plants 12, 15, 18 (four-leaf stage) and 21 days after cotyledon expansion. Maximum effects of the chemical are secured by spraying at the two- and four-leaf stages for the first and second clusters, respectively.

RECOMMENDATIONS FOR COLD TREATMENT

These recommendations are based on more than 50 plantings of tomatoes over a 3-year period seeded from October to March under commercial as well as experimental greenhouse conditions.

(1) Germinate the seed at a temperature of 75-80° F. in the usual manner using sterilized flats of soil, sand, vermiculite, or a mixture of the three.

(2) When the first true leaf begins to show (Fig. 4, plant at left front), either before or after transplanting, grow the young plants for 3 weeks at a night temperature of 50-55° F. The temperature in the plant house may be lowered or the plants transferred to a cooler area. If necessary, transplanting or pricking-off from seedling flats may be done during the cold treatment. Daytime temperatures higher than 50-55° F. often cannot be avoided, and they do not nullify the effects of the cold treatment if night temperatures are kept cool. Expose to as much sunlight as possible.

(3) After 3 weeks of cold, raise the night temperature and maintain it thereafter at 58 to 65°F., depending on the season of the year, the amount of light, and the variety grown.

(4) Give seed tomatoes the cold treatment 10 days to 2 weeks earlier than normal. They will grow very slowly during the cold treatment. Steam-sterilized soil should be used; otherwise, more than the normal loss of plants may result from "damping-off".

(5) The cold treatment does not affect early fruit set, even though it results in many more flowers. Insure fruit set by regular (daily) vibration of the flowers with an electric or battery-operated pollinating device.[2]

RECOMMENDATIONS FOR CHEMICAL TREATMENT

Recommendations for the chemical (N-m-tolylphthalamic acid) treatment of tomato seedlings are given for growers who are experimentally inclined. Its proper use offers great possibilities. This relatively new chemical should not be confused with "Sure-Set", "Blossom-Set", "Tomato-Tone" or any other materials applied to tomato blossoms to increase the set of fruit. They are "fruit-setting" chemicals, while N-m-tolylphthalamic acid as described here is a

[2]The vibrator used was supplied by R. Zinn, 25 West Schaaf Road, Cleveland 9, Ohio.

"flower-forming" chemical. (This is not the only chemical which will stimulate flowering in the tomato. An entire family of N-arylphthalamic acids are effective and some appear fully as beneficial as N-m-tolylphthalamic acid).

(1) Prepare the spray mixture immediately before using. Add 3½ grams of the commercial formulation[3] to 1 gallon of water (1 ounce to 8 gallons). Tap water may be used. Shake well before using.

(2) Time the spray applications as follows: (a) To obtain increased flower numbers on the first cluster, spray when the first two true (plumule) leaves are 1 to 2 inches in length (Fig. 4, plant at right front). This is usually 2 weeks after the seedlings have emerged, and 9 days after the seed leaves have unfolded.

(b) Spray when four to five true leaves have appeared to obtain increased flower numbers on the second cluster (Fig. 4, plant third from left, back row).

(c) To obtain increased flower numbers on the third cluster, spray when seven to eight leaves have appeared and so forth. Experimentally, the first five clusters have been influenced by successive spray applications timed at three-leaf intervals. This is the usual number of leaves occurring between successive flower clusters.

(3) Spray as a fine mist, wetting the leaves and growing parts until the spray begins to run off[4].

One gallon of solution should treat approximately 1,000 plants of the smallest size (to affect the first cluster); proportionately more will be required for older plants with greater leaf area. Since the chemical solution is very weak (200 p.p.m.) and since it must be sprayed on the plant 4 to 6 weeks before the flowers open in the designated cluster, there are no harmful residues and the fruit will not be affected as to quality or composition. The chemical breaks down rapidly and the spray solution should always be made up fresh and used within 2 to 3 hours. Any left over should be discarded. Spray materials running onto the soil or left in the sprayer will leave no harmful residue —decomposition is very rapid.

(4) After chemical treatment, the leaves of tomato seedlings may droop or flag downward for several days. The plants may also

[3]"Duraset-20W".
[4]The sprayer used a ½ pint or quart self-contained air pressure sprayer operated at between 75 and 100 pounds pressure.

appear slightly wilted. Later, the leaves may turn darker green in color. As a result of the chemical treatment, one or two large misshapen flowers and fruit may occur on each cluster. This is not a serious disadvantage since they can easily be removed during pruning.

Concentrations of the chemical higher than recommended or an excessive dose of the recommended concentration will cause many plants to "top-off" after the first treated cluster. Growers should not, however, be too alarmed because a strong sideshoot will usually develop and soon replace the leader.

(5) The chemical treatment to increase early flower numbers does not affect early fruit set. As with the cold treatment, thorough vibration of the flowers to insure pollination is necessary.

(6) Treat only a small part of your crop the first year.

FERTILIZER RECOMMENDATIONS

Higher early and total yields of acceptable well-sized fruit will result only if the increased numbers of flowers are properly pollinated and high but balanced levels of soil fertility are maintained. Sufficient fertilizer and adequate water must be supplied to the "cold" or chemically treated plants to maintain a vigorous vegetative growth. Otherwise, fruit development will be seriously retarded, resulting in a large number of small fruit which do not mature to marketable size.

Additional top or side dressings of fertilizer will be required in most situations. Use these side dressings in addition to the usual manure, phosphate, and potash (0-20-20), and other essential elements applied to the ground beds before setting the plants.

(1) *Fertilizing plants in pots before transplanting.* Apply an all-soluble fertilizer[5] at 7- to 10-day intervals. Use ½ ounce per gallon when watering.

(2) *Fertilizing at transplanting.* Apply an all-soluble fertilizer. Use 1 ounce per gallon of water, with ½ to 1 pint per plant.

(3) *Fertilizing from transplanting until plants have 10 to 15 fruit set.* Apply 150 pounds per acre of a mixture of di-ammonium and mono-potassium phosphates[5] every 10 days or 2 weeks or whenever plants are irrigated. If convenient, add the fertilizer

[5]For example; 10-52-17, 10-50-10, 15-52-9 and other fertilizers with a similar analysis. These are primarily mixtures of di-ammonium and mono-potassium phosphates. Recommendations in pounds per acre may be converted to pounds per square foot on the basis of 43,560 square feet in an acre.

in water (½ to 1 ounce per gallon or 2 to 5 pounds per 100 gallons during or before watering).

(4) *Fertilizing after 10 to 15 fruit set and until four or five good clusters have set*: Apply 75 pounds per acre of the di-ammonium and mono-potassium phosphate mixture and 75 pounds per acre of potassium nitrate. Apply every 7 to 10 days until about a week before the first fruit ripens.

(5) *Fertilizing after four or five clusters have set until plants are topped*: Discontinue the use of the phosphate mixture and fertilize only with potassium nitrate. Use 150 pounds per acre at about 10-day intervals and preferably when heavy irrigations are applied. Under these conditions of high potash fertilization, a magnesium deficiency may occur. If so, add magnesium sulfate, at the rate of 200 to 500 pounds per acre.

These fertilizer recommendations are for growers who obtain increased flower numbers and a greater set of fruit on the early clusters from the cold and chemical treatments outlined. The thickness of the stems near the growing tip, the size of the leaves and flowers, and leaf color should be watched closely and should serve continually as guides in using fertilizer.

Fig. 5. Thick-stemmed tomato plants with large green leaves are necessary for top yields when growers use chemical or cold treatment. (Roy Burghart Greenhouse, Greenville, Michigan.)

Produce thick-stemmed tomato plants with large green leaves and large flower and fruit clusters (Fig. 5). By using more fertilizer and water, preferably in combination, large fruit clusters can be matured to good size. By using the program outlined here, you can grow a good crop of firm fruit without creating an excess soluble salt accumulation in the soil. Fertility levels of greenhouse soils that should be maintained to achieve maximum yields of tomatoes have not been determined.

ECONOMICS OF IRRIGATING IN MICHIGAN

By C. R. HOGLUND, E. H. KIDDER and K. A. VARY[1]
DEPARTMENTS OF AGRICULTURAL ECONOMICS AND AGRICULTURAL ENGINEERING

SPRINKLER IRRIGATION SYSTEMS are a recent development in humid-area farming. This growing interest is largely due to the high returns received from the specialized crops grown on the lighter soils. The development of lightweight, portable irrigation equipment is an additional factor. Finally, there is a growing awareness of the water and nutrient requirements for optimum plant growth. This emphasizes the importance of supplying both water and plant nutrients in the proper amounts at the right time.

Under what conditions does it become profitable for a farmer to invest in irrigation equipment? How large an investment is required for farms of different sizes and situations? These are only two of the questions that prompted the departments of agricultural economics and agricultural engineering to make a study of irrigation on Michigan farms.

Major objectives of the study were to obtain information on crops irrigated, acres of crops irrigated per farm, yields, water sources, kinds of power and equipment used, investments, and expenses and receipts associated with irrigation farming.

During 1953, 176 farmers were interviewed. Information was obtained on their farm organization, irrigation equipment used, water supply, yields of irrigated and nonirrigated crops, investments and experiences. These 176 farms were located in 46 counties in the lower peninsula of Michigan.

Almost three-fourths of the farms were concentrated in three areas in which crop production is specialized. These included the western

[1]Appreciation is given to Boyd C. Wiggins who assisted with the fieldwork and the tabulation of the data. The authors acknowledge the suggestions and assistance received from E. C. Rossman, M. B. Tesar, and E. J. Wheeler of the department of farm crops; R. L. Carolus, H. D. Hootman, and S. H. Wittwer of the department of horticulture; and R. Barlowe and R. G. Wheeler of the department of agricultural economics, in setting up and completing the study. The authors also wish to express their appreciation to the farmers and the county agricultural agents who cooperated in the study. K. A. Vary is now with the Tractor and Implement Division of the Ford Motor Company.

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Fig. 1. Relatively lightweight aluminum pipe has taken much of the drudgery out of irrigation. However, moving pipe may take most of two workers' time for 2 to 3 months.

fruit and truck crop area, the truck crop area near metropolitan Detroit, and the Montcalm potato area. The rest of the farms were located in 20 counties, mostly in southern Michigan.

More detailed information on investments, expenses, and income were obtained from a limited number of farmers during the early part of 1956. This information was used in making an economic appraisal of irrigation on farms of different sizes. An economic analysis was also made of irrigation research data from the departments of agricultural engineering, animal husbandry, farm crops, and horticulture.

ECONOMIC CONSIDERATIONS

The major justification for investing money in an irrigation system is to increase net income. This greater net income can result from higher production or better quality of crops, fruits, or vegetables, or from both.

Many farmers irrigate crops to reduce the year-to-year variation in yields because of seasonal moisture shortages. This may or may not increase average net returns for a period of years, but it can insure against complete crop failures from drought.

The profit of irrigation is determined by such important factors as the cost of applying water, the yield response of crops when ir-

rigated and their gross value per acre, soil type, and acres irrigated per farm.

In general, irrigation appears to be most profitable when used on such high-value crops as strawberries, raspberries, potatoes, sweet corn, tomatoes, and other truck crops. The need for irrigation is usually greater on the lighter than on the heavier soils. A high percentage of the small fruits, vegetables, and potatoes are grown on these lighter soils in Michigan.

The problem of supplying enough water to crops varies greatly from year to year and from week to week, due to differences in stage of growth, rainfall and temperature. The mere application of water when it is needed is not enough in itself—it must be applied in the right quantity and be balanced with sufficient plant nutrients. Fixed costs of owning an irrigation system must be charged each year, regardless of whether the system is used to its capacity or not at all.

Each individual farmer will need to calculate the potential net returns of irrigating the present crops grown on his farm. It may be necessary for him to add some higher-value crops to justify an invest-

Fig. 2. It becomes profitable to apply more fertilizer and to increase the number of plants per acre when irrigation water is applied to crops.

ment in an irrigation system. A farmer may need to irrigate several crops in order to keep labor profitably employed during the entire season. A good example is the addition of pickling cucumbers to a farm where potatoes are irrigated.

Irrigation will not be profitable for some farmers because the crops they produce do not respond enough to pay for added overhead and operating costs.

EFFECT OF IRRIGATION ON CROP YIELDS

The response of crops to irrigation varies considerably from crop to crop. Yields are increased more for some crops than others. Some crops show little or no response to irrigation during seasons of abundant and well-distributed rainfall.

TABLE 1—Range and average crop yields with and without irrigation as estimated by farmers irrigating specific crops, 1952-53

Crop	Irrigated		Non-irrigated		Increased with irrigation*	
	Range	Average	Range	Average	Average	Percent
Potatoes (bu.)	100–686	405	75–425	244	161	66
Strawberries (16 qt. crate)	90–600	260	75–300	160	100	62
Raspberries (16 qt. crate)	38–102	73	18–65	43	30	70
Tomatoes (bu.)	250–800	483	167–400	273	210	77
Snap beans (ton)	3–6	4	1½–2	2	2	100
Sweet corn (doz.)	500–1,400	786	200–800	418	368	88
Cucumbers (bu.)	100–400	260	50–200	135	125	94
Celery (crates)	800–1,000	887	400–500	433	454	105
Melons (bu.)	350–1,000	617	250–500	375	242	64
Onions (bu.)	500–675	637	375–500	425	212	50
Field corn (bu.)	65–140	101	38–75	58	43	74

*Part of this increased yield resulted from the use of greater quantities of fertilizer and higher plant populations.

FARMERS' ESTIMATES OF YIELD RESPONSES

The 176 farmers were asked to estimate their crop yields on the basis of both irrigated and nonirrigated acres for the years 1952 and 1953. Averages, as well as ranges in the yields of principal crops grown, are shown in Table 1.

The data reported give an indication of the possible increases in yield that can be obtained from irrigation of high-return crops grown on light soils. Part of these increases should be credited to additional fertilizer and to more plants per acre.

EXPERIMENTAL RESULTS

Field experiments conducted by the departments of farm crops, animal husbandry, and agricultural engineering showed that the yield of alfalfa—Ladino clover—brome grass pasture was increased by 18 percent when irrigated (Table 2)[2]. Milk production was increased 19 percent on the irrigated pasture. These yields were increased the most in 1953 and the least in 1952.

Corn yields were increased by 12 to 35 percent on an Eaton County farm, and by 27 to 111 percent on a St. Joseph County farm, by the use of irrigation during a 3-year period, 1953-1955 (Table 3)[3]. The soils on these farms were Fox sandy loam and Warsaw sandy loam, both of which tend to be droughty. Corn yields were increased by the greatest percentages on both farms in 1953, an extremely dry season.

Yield responses were the lowest on the Eaton County farm in 1954; on the St. Joseph County farm, in 1955. Corn yields on the irrigated areas would have been higher in 1955 if more water had been applied.

Some corn hybrids responded more than others to irrigation. Other hybrids yielded exceptionally well without irrigation; therefore, they did not show a great yield response when water was applied. It is important to select corn hybrids that consistently yield well under irrigation.

[2]Tesar, M. B.; L. H. Blakeslee and E. H. Kidder (1956). Unpublished data. Mich. Agr. Expt. Sta.
[3]Rossman, E. C. (1956). Corn hybrids compared (1956). Mich. State Univ. Ext. Folder 67. 15 pp.

TABLE 2—Tons of forage and pounds of milk produced per acre on irrigated and nonirrigated alfalfa—Ladino clover—bromegrass pasture on a Fox sandy loam soil, W. K. Kellogg Farm, Calhoun County, 1952-1954

Pasture	1952	1953	1954	3-year average
Tons forage produced*				
Irrigated	4.08	4.63	5.52	4.74
Nonirrigated	3.77	3.50	4.79	4.02
Increase with irrigation	.31	1.13	.73	.72
Percent increase	8.2	32.3	15.2	17.9
Pounds milk produced				
Irrigated	3,190	4,520	5,050	4,250
Nonirrigated	3,020	3,330	4,350	3,570
Increase with irrigation	170	1,190	700	680
Percent increase	5.6	35.7	16.1	19.0

*Based on 12 percent moisture.

*TABLE 3—Yield of irrigated and nonirrigated corn for two hybrid corn test demonstration farms, 1953-55**

	Number of hybrids tested	Plants per acre	Irrigated		Non-irrigated		Percent increase
			Range	Average	Range	Average	
			bushels per acre				
Eaton County†							
1953	15	15,600	105–147	124	80–124	92	35
1954	20	15,600	107–157	135	103–142	121	12
1955	36	17,000	78–126	104	64–106	90	16§
St. Joseph County‡							
1953	15	15,600	66–90	78	30–50	37	111
1954	20	15,600	88–126	103	52–85	69	49
1955	36	15,700	89–124	102	57–100	80	27§

*Adapted from Rossman, E.C. (1956). Corn hybrids compared. Mich. State Univ. Ext. Folder 67. 15 pp.
†Fox sandy loam.
‡Warsaw sandy loam.
§Yields would probably have been increased by a higher percent if more water had been applied.

Experimental work carried out by the departments of horticulture and agricultural engineering pointed out the variation in response of truck crops to irrigation[4]. During a 5-year period (1948-1952), tomato yields were increased by 20 to 66 percent, snap bean yields by 6 to 42 percent, and sweet corn yields from no increase to 126 percent. Yields were increased the most during 1948 when the growing season precipitation was only 74 percent of the long-time average.

INVESTMENT IN AN IRRIGATION SYSTEM

The total investment in an irrigation system may vary from as little as $700 to as much as $50,000. The size of investment is determined by such important factors as: (1) The acres irrigated, (2) the decision to purchase new or used equipment, (3) the source and the location of the water supply, (4) competition between dealers, and (5) services purchased in designing and installing the system.

THE WATER SUPPLY

Local circumstances largely determine the investment needed to supply the right amount of water. The farmer who has a large stream or river running through his farm may need make no further investments in securing a water supply. Prospective irrigators will need to

[4]Schleusner, P. E.; F. W. Peikert and R. L. Carolus (1949). Results of irrigation on vegetable crops. Mich. Agr. Expt. Sta. Quart Bul. 31: 343-350. Also, Carolus, R. L., and P. E. Schleusner (1950). Effects of irrigation on snap beans, sweet corn, and tomatoes as influenced by certain cultural practices in 1949. Mich. Agr. Expt. Stat. Quart. Bul. 32: 346-478.

determine whether there are any water right problems in the use of surface sources of water.

Ponds and reservoirs were used by more than 40 percent of the farmers who irrigated less than 30 acres. These are inexpensive to build, but often they do not supply enough water later in the growing season. The 1953 study showed a construction cost of from $80 to $1,000 for reservoirs.

Farmers irrigating 30 or more acres are heavier users of deep wells as a source of water. The use of deep wells may not be a matter of preference with the individual irrigator; it may be the only adequate source of water available.

The size of wells most commonly reported were 8 inches and 10 inches in diameter. Well depths varied greatly from shallow wells of only a few feet to deep wells of over 400 feet, depending on the distance to an adequate underground water supply. The diameter of the well cannot be taken as an exact indicator of the quantity of water that can be pumped. The underground water-bearing material largely determines the quantity of water available from a particular size of well.

The total cost of deep wells differed greatly, depending upon the need for a test well, material encountered in drilling, type of drilling equipment used, development, type and footage of screen needed, depth of well, and competition between drillers.

Fig. 3. Portable, lightweight irrigation equipment is especially well-adapted to a farm where a stream, ditch, or lake provides the water.

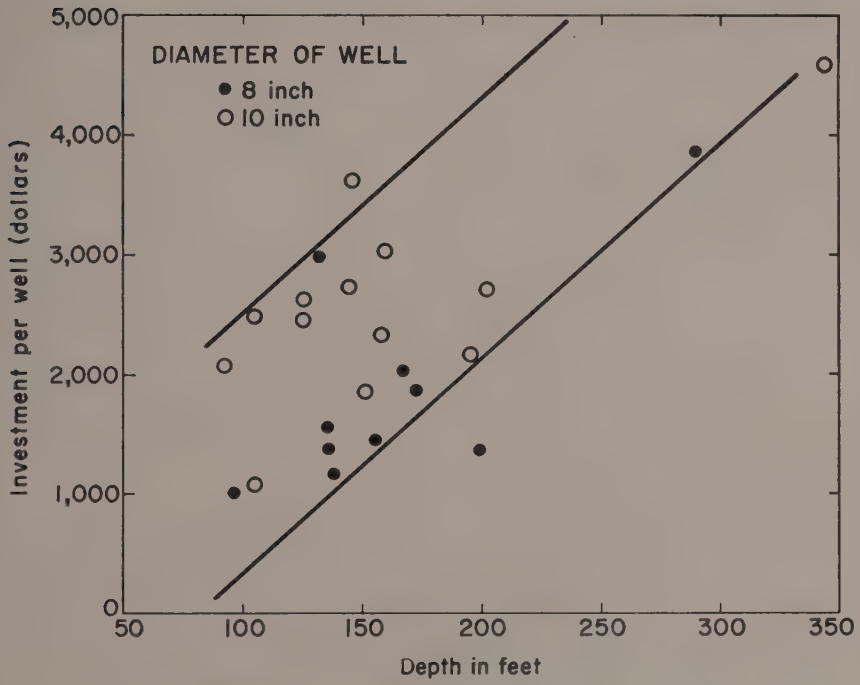

Fig. 4. Relationship of depth and diameter of well to investment. Cost of wells of the same diameter and depth vary greatly because of differences in material encountered in drilling equipment used, test wells drilled, type and quantity of screen needed, and competition between drillers. The lines in this graph indicate the most common range in investments per well.

Complete information on 10 8-inch diameter wells showed a range in depth from 95 to 290 feet and in cost from $1,060 to $3,850 (Fig. 4). Thirteen 10-inch diameter wells ranged in depth from 90 to 340 feet and in cost from $1,100 to $4,600.

In general, deep wells are considered more dependable sources of water than surface sources. Several of the farmers depending on small streams reported an inadequate supply of water late in the growing season. Wells are also less likely to cause conflicts in water rights.

POWER AND PUMPING UNITS

The power and the pumping unit are important parts of an irrigation system and should be engineered to the needs of an individual farm. In buying this equipment, farmers should consider their source

of water, the acres of different crops to be irrigated, the length of main and lateral lines, and the distance water is lifted.

Power

Most Michigan farmers use stationary gasoline engines for power, either air-cooled or water-cooled. Air-cooled engines are used chiefly on the smaller systems, while water-cooled motors are used on all sizes.

The gasoline engine is particularly well-adapted to the portable "packaged" pump and power unit. The engine speed can be changed to meet the operational demands of the system. One of the objections to gasoline engines expressed by many irrigators was the relatively high cost of upkeep. Farmers using air-cooled engines reported more repairs than those using water-cooled engines. A common trouble was sticking valves.

In areas where three-phase power is readily available, the electric motor represents a very desirable, low-maintenance source of power that is especially adapted for use on deep-well turbines. A few farmers used single-phase motors to operate small deep-well pumps

Fig. 5. The electric motor is a dependable, low-maintenance source of power that is well-adapted to deep-well turbines.

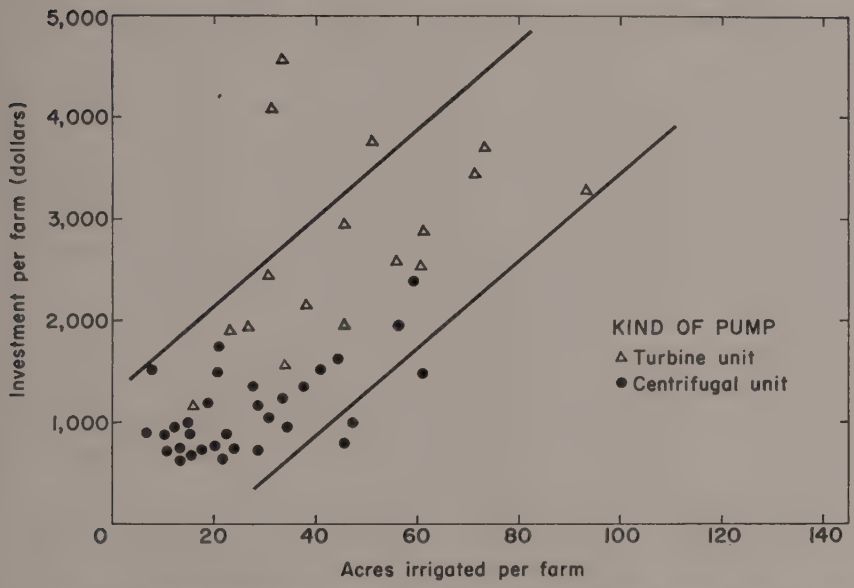

Fig. 6. Investment in centrifugal and turbine pumps and power units. Some farmers purchased pump and power units which were larger than needed for their present acres irrigated. This resulted in a wide range of investments for farmers irrigating the same acreage. Second-hand equipment was purchased at prices ranging from 25 to 75 percent the cost of new equipment. The lines indicates the most common range of investment in pump and power units.

discharging into reservoirs. One objection to the electric motor is that its fixed speed of operation does not permit any change in pump speed to meet varying operational demands.

Pumps

Horizontal centrifugal pumps adapted to irrigation needs are usually found on farms with surface sources of water or shallow wells. These pumps do not operate satisfactorily when the water is more than 20 to 22 feet below the pump level. A deep-well turbine pump is required if depth to water when pumping is below this level. The amount of money invested is determined by pumping depth, size of pump, pressure required, length of pump column, and size of power unit.

Farmers may expect to invest from $600 to $2,500 for a centrifugal pump and power unit when the acres to be irrigated range from 5 to 60 (Fig. 6). This investment ranged from $2,000 to more than $4,000 per farm when the deep-turbine pump and power unit was

used to irrigate from 30 to 100 acres of crops. A few farmers who irrigated more than 100 acres had invested from $5,000 to $7,000 in the pump and power unit.

DISTRIBUTION SYSTEM

A very high percentage of the irrigation systems used in Michigan are portable. A few irrigators used buried main lines with portable submains. Before 1945, steel pipe was mostly used. The increased supply of aluminum alloy tubing since then has resulted in a complete shift from steel to aluminum. The principal reasons for this trend to aluminum pipe are its lighter weight and its availability in preferred lengths of 20 and 30 feet. The combined cost of main and lateral varied from $175 to $16,000 per farm, depending on diameter and quantity of pipe used, as well as on the price paid per foot.

Main Lines

The average length of main line used per farm generally increased as more acres were irrigated. The length of main line needed depends on the distance from water to the individual fields. When irrigation water is carried to more than one area of a farm, the length of the main line may equal or exceed the length of the lateral lines. The length of main lines ranged from 300 to 4,000 feet on most of the farms studied.

In general, the diameter of mains should be increased with the acreage irrigated. The 3- and 4-inch diameter mains were most commonly used on farms where less than 10 acres were irrigated. The 4-, 5- and 6-inch diameter mains were important sizes on farms where 10 to 59 acres were irrigated. The 6-inch and larger mains were used on farms where 60 or more acres were irrigated.

Laterals

The amount of lateral pipe needed per farm depends on: (1) the acreage irrigated, (2) additional lines planned for frost protection, and (3) additional lines for greater convenience and savings in labor in moving lines. Additional pipe makes it possible to move one line to a new location while a second one is in operation. This adds to the investment, but it does reduce operating time lost in moving pipe.

The size of pipe most frequently used for laterals varied from 3 to 6 inches. Some farmers used the same size pipe for both main and lateral lines. The diameter of pipe used should fit each individual farm situation.

Water Applicators

Rotary sprinklers are an important part of almost every irrigation system used by Michigan farmers. These sprinklers are usually operated at pressures ranging from 20 to 120 pounds per square inch. The more common sprinkler capacity varies from 5 to 50 gallons per minute.

A few farmers used higher-capacity sprinklers. An advantage reported was reduced labor time in moving pipe because of the larger area irrigated at one setting. However, the larger-capacity sprinklers required more power because of the higher pressure needed for their operation.

TOTAL INVESTMENT IN AN IRRIGATION SYSTEM

The total invested in a complete irrigation system when purchased new varied from $2,000 to $10,000 when a centrifugal pump was used

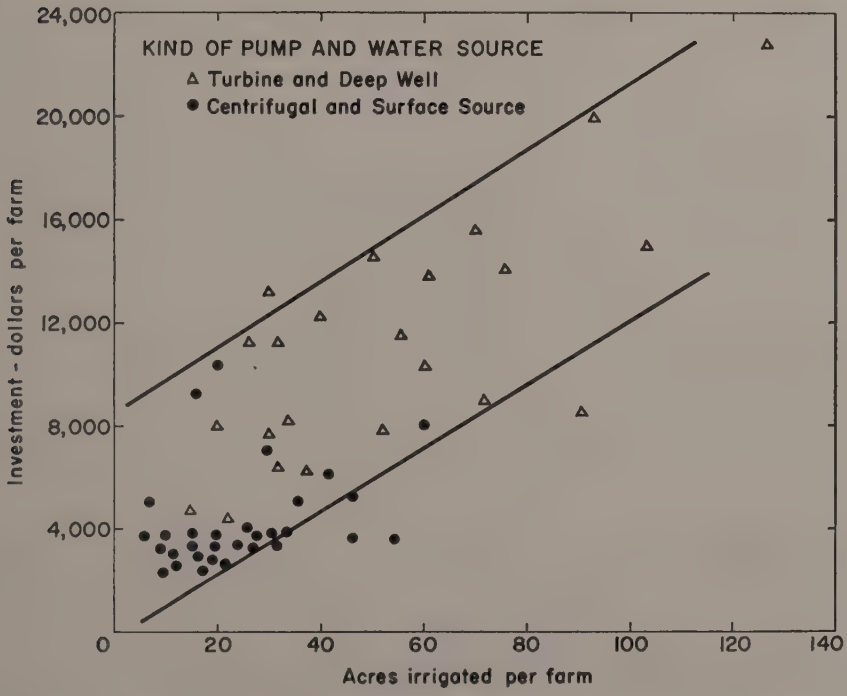

Fig. 7. Total investment in irrigation systems on farms where deep-well and surface sources of water are used. Farmers who use a deep-well turbine pump generally invest $4,000 more in an irrigation system than do farmers who use centrifugal pumps and a surface source of water. The lines indicate the most common range of investment in irrigation systems.

in connection with a surface source of water (Fig. 7). This investment included the cost of constructing ponds and reservoirs when they were used.

The investment in a complete irrigation system where a deep-well turbine pump was used usually ranged from $8,000 to $20,000 when 20 to 100 acres of crops were irrigated (Fig. 7). The investment on some farms was considerably greater than this when higher-capacity pumps and more power were needed to draw water from deeper wells or to pump water for longer-than-average distances.

CHANGES IN EXPENSES AND RECEIPTS

FACTORS AFFECTING COSTS

The cost per acre of applying irrigation water to crops is determined by such important factors as: (1) the source and location of the water supply, (2) the quantity of water applied per acre, (3) how well the equipment is adapted to the irrigation situation on an individual farm, and (4) the acres of crops irrigated per farm.

The farmer who has access to an adequate supply of water from a river, stream, lake, or reservoir usually has a decided cost advantage over the one who must drill a deep well. The farmer who has a satisfactory source of surface water will usually invest from $1,000 to $4,000 less for an irrigation system than the one who must drill a well and purchase the more expensive turbine pump.

On the basis of 15 years of life for the power and pumping equipment and a 30-year life for the well, annual overhead expenses for a deep well would be increased by $75 to $300.

Deep wells usually have the advantage of a more adequate supply of water; they often have an additional advantage in location. It is often possible to drill a well in a more central location, thereby reducing the length of main lines. This saving in pipe may partly offset the additional investment in the deep well and the more expensive pump and power unit.

The expenses in applying different amounts of water have been estimated for a farm on which 60 acres of crops were irrigated. A stream provided the source of water. A 32-horsepower industrial gasoline engine supplied the power. The investment in irrigation equipment totalled $7,600.

On the basis of a 15-year life for this equipment and a 5 percent interest charge on one-half of the investment, annual overhead costs

would total $11.62 per acre (Table 4). This overhead expense per acre would normally range from $10 to $20 on individual farms, depending on the total investment and how fully it was used. This charge would remain about the same, regardless of the number of applications of water per year.

Annual expenses for repairs, labor, fuel, and oil per farm and per acre have also been calculated. The total expense of one application of 2 inches of water totalled $14.99 per acre, or $7.50 per acre-inch. Expenses per inch of water were reduced as additional applications of water were made (Table 4).

TABLE 4—Estimated annual expenses per acre and per acre-inch of applying variable quantities of irrigation water. Based on irrigation of 60 acres, Farm A

Expense item	Number of applications*				
	0	1	2	3	4
Depreciation and interest.....	$11.62	$11.62	$11.62	$11.62	$11.62
Repairs.....	....	.37	.74	1.12	1.48
Labor†.....	....	1.64	2.95	4.08	5.33
Fuel and oil.....	....	1.36	2.72	4.08	5.44
Total expense per acre...	$11.62	$14.99	$18.03	$20.90	$23.87
Expense per acre-inch.....	$	$ 7.50	$ 4.51	$ 3.48	$ 2.98

*Two inches of water applied per application.

†Labor for moving pipe estimated at 1 man-hour per acre. About 8 hours were needed to set up the system in the spring and again to take down and store the system in the fall. When a farmer supplies his own labor, there would be no cash expense for this item.

FACTORS AFFECTING NET INCOME

If irrigation is to show a profit, the value of the extra products produced (after the extra costs of fertilizer, seed, labor, harvesting and other items have been subtracted) must exceed the total cost of applying water. Four applications of water on Farm A would cost about $24 per acre (Table 4). Many low-value crops would not yield the extra returns to cover these costs.

Does it pay to irrigate a relatively low-value crop such as alfalfa-brome? Irrigation of pasture at the W. K. Kellogg Farm resulted in an average increase of 18 percent, or .7 ton of forage per acre. When this forage is valued at $30 per ton, the value of the increased production just equals the cost of applying three 2-inch applications of water (Table 4). These costs are not met when a value of $25 per ton is used.

Fig. 8. Irrigation of pasture is most likely to be profitable if it results in more cows kept or maintains milk output at a higher level, particularly during base-forming time in the fall. Highly fertilized, productive stands are needed for optimum net gains.

The increased pasture production resulted in 680 pounds more milk per acre. When this milk nets $4 per cwt., it has a value of $25.84 which is only slightly more than the cost of applying irrigation water.

It appears that irrigation of pasture or hay will pay only if it permits an increase in the number of cows kept, or if it helps to maintain milk production at a higher level during base-forming time in the fall or at some other critical time during the summer period. Dairy farmers with droughty soils will benefit the most from pasture irrigation.

Irrigation of pastures is likely to be more profitable if a higher-value crop is also irrigated. Additional research is needed to determine the opportunities of increasing net incomes on dairy farms, either by irrigation or by using alternative pasture management practices.

Field corn is another crop which may be on the borderline of being profitable to irrigate. Corn yields on an Eaton County farm were increased by an average of 20 bushels per acre (Table 3). When corn sells for $1.40 per bushel, the value of the extra corn produced is only $28 per acre. Fixed and operating costs of applying 6 or 7 acre-inches of water would cost about $20. Additional expenses for seed, fertilizer and harvesting must be added to this cost. When corn yields are increased by 30 or more bushels per acre (as they were on the St. Joseph County farm), irrigation appears to be more profitable.

TYPICAL FARM SYSTEMS

Three farms will be used to illustrate the effect of source of water supply, kind of crop irrigated, and number of acres irrigated on the amount and kind of equipment needed and its cost. These farms, designated as B, C and D, are believed to be typical of many farms on which strawberries, truck crops, and potatoes are irrigated. It is suggested that these illustrations be used as guides and not as exact figures by farmers who are interested in determining the irrigation equipment and investment needed, and probable costs and returns on their own farms.

Farm B—This farm is typical of the 40- to 80-acre fruit farms in southwestern and western Michigan. Fifteen acres of irrigated strawberries are grown (Table 5). Tree fruit, raspberries and grapes are usually produced on the balance of the acreage. The source of irrigation water is a stream. This farmer uses 840 feet of 4-inch main and 1,520 feet of 3-inch lateral. This system is used for frost protection as well as irrigation. About $3,200 are invested in the irrigation system.

TABLE 5—Investment and fixed costs in owning an irrigation system on three typical farms, 1955 prices

Item	Farm B	Farm C	Farm D
Total acres tillable	62	106	210
Acres irrigated			
Strawberries	15	1	....
Truck crops	....	29	....
Potatoes	....	....	75
Total irrigated	15	30	75
	Dollars	*Dollars*	*Dollars*
Investment in:			
Pump and power unit	1,300	2,000	3,300
Distribution system	1,410	2,180	5,140
Sprinklers, couplings	500	600	840
Reservoir or well	....	400	2,100
Total investment	3,210	5,180	11,380
Fixed cost*			
Annual	295	475	972
Per acre	20	16	13

*Depreciation and interest. Depreciation based on 15-year life of equipment and 30-year life of well. Interest charged at 5 percent on one-half of the investment.

Fig. 9. Strawberries were a major crop grown on the farms where less than 15 acres of cropland were irrigated. Many strawberry growers used their irrigation systems for frost protection in addition to providing supplementary water.

Whether it is profitable to irrigate strawberries will depend on how much yields are increased, what these berries will sell for, and how much it costs to own and operate the irrigation equipment. An additional yield of 50 crates of strawberries selling at $4.00 per crate would add $200 to gross receipts per acre, or $3,000 for the 15 acres. A 100-crate increase would add $6,000 to gross receipts (Table 6).

The fixed (depreciation and interest) costs of owning this system are $295 per year or $20 per acre (Table 6). Cash expenses for repairs, fuel, and oil in operating the irrigation equipment add $235 to costs.

The use of more fertilizer when strawberries are irrigated increases expenses by about $300. About 2 months of extra hired labor to move pipe adds $600 to expenses. A picking charge of $1.20 per crate adds $900 to expenses when yields are increased by 50 crates per acre. These expenses are doubled when yields are increased by 100 crates per acre.

If irrigation results in a 50-crate yield increase, total additional expenses are increased by $2,330; net income, by $670. If strawberry yields are increased by as much as 100 crates per acre, expenses are boosted by $3,230 and net income by $2,770 (Table 6).

TABLE 6—Estimated changes in annual receipts and expenses when an irrigation system is established on a fruit farm where 15 acres of strawberries are irrigated

Item	Additional yield: 50 crates per acre	Additional yield: 100 crates per acre	Value per crate	Additional receipts and expenses when yields are increased by: 50 crates per acre	Additional receipts and expenses when yields are increased by: 100 crates per acre
Additional receipts					
Strawberries	750	1,500	$4.00	$3,000	$6,000
Additional expenses					
Depreciation and interest				295	295
Repairs, fuel and lubricants				235	235
Fertilizer				300	300
Hired labor	(2 mo. at $300)			600	600
Harvesting	($1.20 per crate)			900	1,800
Total additional expenses				$2,330	$3,230
Net increase in income				$ 670	$2,770

Farm C—This is an intensive truck crop farm, typical of the area near metropolitan Detroit or in the southwest area of Michigan. From 20 to 40 acres of truck crops and, often, a few acres of berries or potatoes are irrigated (Table 5).

The water is usually obtained from a stream, reservoir or pond. A typical farm would have about 1,100 feet of 5-inch main line and 1,900 feet of 4-inch lateral lines. The investment in a complete irrigation system, including the cost of a reservoir, would total nearly $5,200.

Fixed costs would average $475 annually, or $16 an acre, when the system was used to its capacity. If this system was used to irrigate 15 rather than 30 acres, per acre costs would average $32 (Fig. 10). This emphasizes the importance of purchasing a system that is adequate but economical for the acreage to be irrigated.

Changes in receipts and expenses resulting from irrigation have not been estimated for Farm C because of the variety of truck crops that might be grown on an individual farm and because of a lack of adequate information on crop requirements and yield responses when irrigation is used on some crops.

However, prospective truck crop irrigators should find the data and methods used in Tables 1, 4, 5, 6 and 7 useful in estimating additional receipts and expenses for their own situation.

Farm D—A detailed study was made of the investment, yields, expenses and net returns on a Montcalm area farm on which 75 acres of potatoes were irrigated. This operation is typical of many farmers who irrigate from 60 to 100 acres of potatoes. Water is pumped from a 10-inch diameter well, 125 feet deep.

Potatoes are a specialized crop which respond well to irrigation. Potato yields have been increased by about 60 percent when from 5 to 7 acre-inches of water have been applied and additional quantities of seed, fertilizer, and labor have been used. Potato growers who have used good management practices have averaged about 300 bushels per acre without irrigation.

The value of an additional 180 bushels of potatoes per acre (priced at $1.00 per bushel) for 75 acres would total $13,500 (Table 7).

The investment in the pump, motor, and the distribution system was $9,280; expenses for a deep well were $2,100. Depreciation, interest charges, and operating expenses are shown in Table 7. These to-

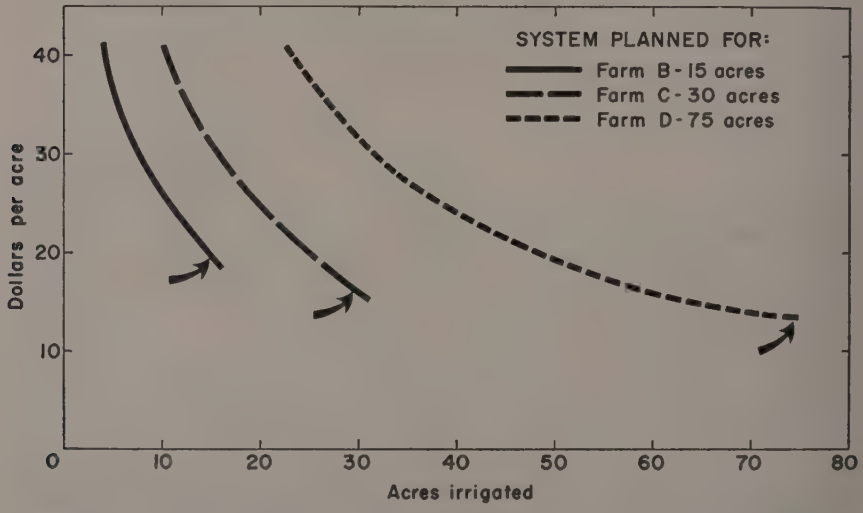

Fig. 10. Estimated annual fixed costs per acre in owning an irrigation system. Arrows point to fixed overhead cost per acre when systems are used to their capacity. These acre costs are increased when the system is used on less than these optimum acres.

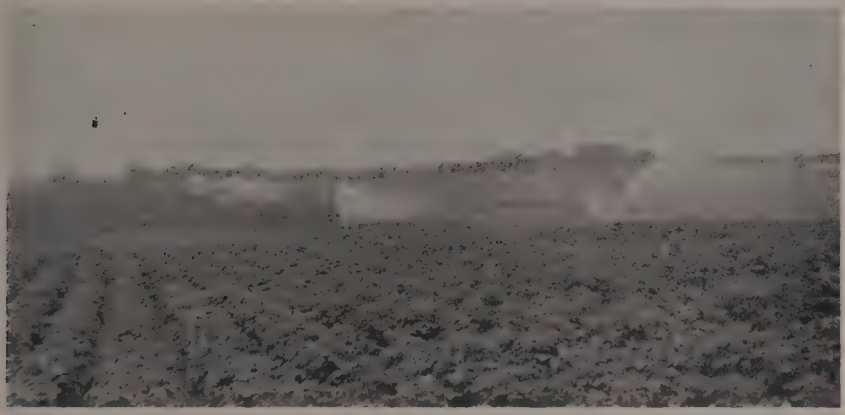

Fig. 11. Potatoes were a major crop on over 50 percent of the farms on which 40 or more acres were irrigated. Some farmers in the Montcalm area irrigated 100 or more acres of potatoes.

tal $1,631 annually. Expenses for extra seed potatoes and fertilizer add up to $3,529. Two men are employed for a 2½-month period to move pipe, adding $1,500 to expenses. Harvesting and trucking the extra potatoes produced adds another $2,700. Total annual expenses are increased by $9,360; additions to net income are $4,140.

Changes in receipts and expenses resulting from irrigation vary considerably from farm to farm, depending on crops grown, makeup and investment in the irrigation system, efficiency with which the equipment is used, and management practices used.

Individual farmers considering the purchase of an irrigation system should estimate the changes that are likely to occur in receipts and expenses if they irrigate. Some farmers will find that investments in improved machinery and equipment, more or better livestock, or other alternatives will pay off better than investments in an irrigation system.

SUMMARY

Sprinkler irrigation has been greatly increased in Michigan in recent years. The development of lightweight, portable irrigation equipment, and the potentialities of increasing both yields and net returns have been important factors contributing to this trend.

Strawberries, raspberries, potatoes, sweet corn, tomatoes and other truck crops are high-value crops which respond well to irrigation.

TABLE 7—Estimated changes in annual receipts and expenses when an irrigation system is established on a Montcalm area farm (75 acres of potatoes irrigated)*

Item	Additional quantity per acre	Acres	Total quantity	Value or cost per unit	Total
Additional receipts					
Potatoes	180 bu.	75	13,500 bu.	$ 1.00	$13,500
Additional expenses					
Depreciation†					688
Interest‡					284
Repairs and lubricants					99
Electric current					560
Seed potatoes	10 bu.	75	750 bu.	2.00	1,500
5-20-20 fertilizer	500 lb.	75	18.8 t.	78.00	1,466
N-sidedressing	50 lb.	75	3,750 lb.	0.15	563
Hired labor			5 mo.	300.00	1,500
Harvesting and trucking			13,500 bu.	0.20	2,700
Total additional expenses					$ 9,360
Net increase in income					$ 4,140

*Based on 1955 prices and better-than-average management practices.
†Fifteen-year life on pump, power unit and pipes and 30-year life on well.
‡Five percent interest on one-half of investment.

Farmers' experiences and experimental trials have shown that irrigation may have little or no effect on yields during seasons of abundant and well-distributed rainfall. During more normal growing seasons yields may be increased by 20 to more than 100 percent.

In order to benefit fully from irrigation, it is important to apply water at optimum rates when it is needed and to balance this additional water with sufficient plant nutrients. Some farmers have failed to show any appreciable increase in net returns because they failed to use adequate quantities of fertilizer.

Farmers who irrigate less than 30 acres depend largely on surface sources of water. Deep wells become increasingly important as larger acreages are irrigated. Deep wells usually range in depth from 90 to 300 feet and cost from $1,000 to $4,000. Except for large lakes and streams, deep wells are more dependable than surface sources.

Farmers who irrigate less than 10 acres tend to use 3- and 4-inch diameter main lines. The more common sizes for larger acreages irrigated are the 4- and 6-inch diameter mains. The 8-inch main is often

used for the largest acreages. Lateral lines are usually 2 and 3 inches in diameter when less than 10 acres are irrigated and 3 and 4 inches when 10 to 80 acres are irrigated. The 6-inch main is commonly used when 80 or more acres are irrigated.

Strawberry and truck crop growers have made increased use of irrigation for frost protection. Designing a system for both supplementary water and frost protection adds considerably to length of lateral lines and to investment. Some farmers use this additional pipe during the irrigation season in setting up a new location while another line is still in operation. This reduces irrigation time lost in moving pipe.

Investment in a complete irrigation system may range from as little as $700 to over $50,000. The more usual range is between $2,000 and $10,000 when a farmer uses a centrifugal pump and has a surface source of water. When farmers depend on a deep well and the more expensive turbine pump, they usually invest from $8,000 to $20,000 for a complete system.

The profitableness of irrigation depends on how much yields are increased, the value of the increased yield, acres irrigated, cost of applying water and other costs of producing and marketing the extra yield. Reduced variability in crop yields and increased quality are additional factors which should be considered.

Depreciation and interest (overhead costs) on the investment in an irrigation system will usually average from $10 to $20 per acre annually. This cost continues regardless of how fully the system is used. Individual farmers will need to calculate the cash expenses for repairs, fuel and oil in operating the irrigation equipment, and extra labor and fertilizer in irrigating, growing and marketing the extra production. These estimated operating expenses plus the overhead costs can then be deducted from the estimated value of the increased production in determining whether it will be profitable to invest in an irrigation system.

Strawberries, raspberries, potatoes and truck crops are most likely to show a profit from irrigation. Irrigation of a relatively low-value crop such as pasture is less likely to be profitable unless it results in more cows kept or maintains milk output at a higher level during base-forming time in the fall.

EWE AND LAMB GAINS ON BROME AND REED CANARYGRASS PASTURE

By L. H. BLAKESLEE, C. M. HARRISON and J. F. DAVIS[1]

Reed canarygrass *(Phalaris arundinacea L.)* is well adapted for pasture on many of the several million acres of Michigan's poorly drained or flooded organic soils. On the better drained areas of such soils, both reed canarygrass and smooth bromegrass are well adapted.

The question often arises as to which of the two grasses, when pastured, would be more easily managed or be the most productive of animal gains. Steers pasturing on reed canarygrass made inconsistent gains regardless of management.[2]

To gather information on the comparative values of the two grasses on well drained organic soil, an experiment was designed to test the two grasses with ewes and lambs as grazing animals.

EXPERIMENTAL PROCEDURE

In August 1952, an area of drained muck was selected and fertilized with 500 pounds per acre of 0-9-27 containing 10 percent of copper sulphate. On August 12, alternate duplicate plots, each .9 acre in size, were seeded to reed canarygrass and smooth bromegrass. The plots were fenced, and ewes with lambs were allotted to each area in the spring of 1953, 1954, and 1955 on May 13, 11, and 12, respectively.

As the pasture season progressed and after weighing at 2-week intervals, ewes with their lambs were removed or added as necessary.

Gains or losses for ewes and lambs over the 3-year period are summarized in Table 1. Table 2 shows the pattern of gains by weighing periods as well as carrying capacity.

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[1]Departments of animal husbandry, farm crops, and soil science, respectively.

[2]Van Arsdell, W. J.; G. A. Branaman, C. M. Harrison and J. F. Davis (1954). Pasture results with steers on reed canarygrass. Mich. Agr. Expt. Sta. Quart. Bul. 37: 125-131.

ARTICLE 39-20

MANAGEMENT OF THE EWES AND LAMBS

The ewes started lambing on April 1 in 1953 and 1954 and on March 1 in 1955. All ewes and lambs were dipped for ticks and lice and drenched with phenothiazine for worms before going to pasture. Ewes and lambs were all drenched for worms in June and again in July or August, if necessary. A mixture of one part phenothiazine and 14 parts of salt was kept in a covered salt box before the sheep at all times, and portable shades 8 feet by 12 feet were provided.

The ewes and their lambs were pastured on the plots until September 1, 1953, when all were removed. In 1954, the lambs were removed August 24 and the ewes September 7. In 1955, the lambs were weaned on July 18, and the ewes remained on the pasture until September 6.

DISCUSSION OF RESULTS

Pounds of lamb per acre and daily gains:

The summary of three pasture seasons showed favorable results with ewes and lambs for both canary and bromegrass. There were, however, several differences in performance of the lambs and ewes. As shown in Table 1, the reed canarygrass produced the greatest yield in pounds of lamb per acre because of a higher carrying capacity. This was true each year, with the greatest yield of 332.7 pounds in 1953.

Whereas the daily gain per lamb was similar in the years 1954 and 1955, the total gain per acre was less because of lower carrying capacity and fewer grazing days for the lambs before they were weaned and removed from the pasture.

While total lamb gains were greater on the plots of canarygrass than on bromegrass (249.6 as against 226.6 pounds), the lambs on bromegrass made greater daily gains. The average daily gain for the 3 years was .348 for reed canarygrass and .447 for bromegrass.

Table 1 shows the gain of the ewes on pasture each year. Over the pasture period, the ewes in the canarygrass pastures gained weight 2 years and lost 1 year, with an average gain over the 3-year period of 2.5 pounds per ewe. As long as the lambs make satisfactory daily gains, the yield in pounds of lamb per acre may be considered more important than the gain or loss in ewe weights.

In the bromegrass pastures, the ewes gained each year with a season average of 18 pounds per ewe. The ewe gains on a seasonal per acre basis show 17 pounds for reed canarygrass and 75 pounds for bromegrass.

TABLE 1—Record of sheep gain or losses on reed canarygrass or smooth bromegrass on duplicate plots: 1953, 1954, and 1955

Year	Reed canarygrass								Bromegrass							
	Lambs				Ewes				Lambs				Ewes			
	Number per acre	Daily gain	Total gain per acre	Lamb days per acre	Number per acre	Gain or loss per acre	Ewe days per acre	Gain ewes and lambs per acre	Number per acre	Daily gain	Total gain per acre	Lamb days per acre	Number per acre	Gain or loss per acre	Ewe days per acre	Gain ewes and lambs per acre
	av.	lbs.	lbs.		av.	lbs.		lbs.	av.	lbs.	lbs.		av.	lbs.		lbs.
1953 ..	8.37	.357	332.7	930	7.0	11.6	784	344	6.05	.447	300.5	673	4.68	120.5	520	421
1954 ..	7.66	.341	275.5	808	7.3	—3.3	878	272	5.36	.450	242.0	537	4.37	37.2	521	279
1955 ..	6.11	.340	140.5	411	5.9	42.8	698	183	4.44	.440	137.0	311	3.44	68.3	403	205
3-year av..	7.6	.348	249.6	716	6.8	17.0	787	266	5.3	.447	226.	507	4.10	75.0	481	301

These results indicate that the greater total gain of lambs on canarygrass was made partly at the expense of ewe body flesh. Considering fat or finish, there was no indication that the lambs pastured on canarygrass were of lower quality than lambs pastured on bromegrass.

Days pastured and sheep or lambs per acre:

The data on days pastured and rate of stocking pastures is summarized in Table 1. Table 2 gives more detailed summary on rate of stocking pastures for the year 1953.

Total ewe days on reed canarygrass in 1954 showed an increase over 1953, while there was a decrease on the bromegrass pastures. Lamb gains likewise showed a small decrease for 1954 when compared to 1953. A comparison of ewe days between canarygrass and bromegrass gave an average per acre for 3 years of 786 ewe days for canarygrass and 481 for brome. This gives an average of 6.7 ewes per acre for reed canarygrass and 4.1 per acre for brome.

The lambs were weaned earlier each year; they were pastured 111, 105 and 67 days, respectively, for 1953, 1954 and 1955. The number of lambs per acre likewise decreased each year, showing an average per acre for the 3 years of 7.5 for canarygrass and 5.3 for bromegrass.

SUMMARY

1. Duplicate .9-acre pasture plots of well drained organic soil were seeded to reed canarygrass and northern smooth bromegrass in August 1952; they pastured with ewes and their lambs during the following three pasture seasons.

2. Lambs, with their dams, gained an average over the 3 years of .348 pounds per day on duplicate reed canarygrass pastures; comparable lambs on bromegrass areas gained .447 pound per day.

3. Because of greater carrying capacity, the reed canarygrass produced 333 pounds of lamb per acre the first year and averaged 249.6 pounds over the 3-year period. The bromegrass produced 300 pounds per acre the first pasture season and averaged 226 pounds for the three seasons.

4. The dams of the lambs made better gains on bromegrass each pasture season, averaging 75 pounds per acre over the 3-year period in comparison with 17 pounds per acre for reed canarygrass.

TABLE 2—Gains and losses of ewes and lambs from two .9-acre plots of reed canarygrass, 1953

Grazing period	Ewes			Lambs				Ewes and lambs		
	Number	Gain or loss per ewe	Total gain or loss	Number	Gain or loss per lamb	Total gain	Daily gain per lamb	Sheep days	Lamb days	Total gain
		lbs.	lbs.		lbs.	lbs.				lbs.
5/13-26	16	13.0	208	21	8.0	168	.61	208	273	376
5/26-6/9	22	−6.9	−153	28	5.3	150	.38	308	392	− 3
6/9-23	17	−3.1	− 53	23	5.0	116	.36	238	322	63
6/23-7/7	9	−2.4	− 22	9	5.0	45	.36	126	126	23
7/7-21	9	2.6	24	9	3.2	29	.23	126	126	53
7/21-8/4	9	−3.3	− 30	9	2.4	22	.17	126	126	− 8
8/4-18	10	4.7	47	11	4.0	44	.29	140	154	91
8/18-9/1	10	0.0	0	11	2.3	25	.16	140	154	25
Totals	..	....	21	..	....	599		1,412	1,673	620
Av. per acre	..	....	11.6	..	....	332.7		784	930	344
Gains and losses of ewes and lambs from .9-acre plots of bromegrass, 1953										
5/13-26	16	12.7	204	20	9.8	195	.75	208	260	399
5/26-6/9	10	−1.4	− 14	14	6.9	96	.49	140	196	82
6/9-23	7	4.0	28	9	8.0	72	.57	98	126	100
6/23-7/7	7	−3.2	− 23	9	5.2	47	.36	98	126	24
7/7-21	7	4.0	28	9	5.3	48	.38	98	126	76
7/21-8/4	7	−1.1	− 8	9	3.6	32	.25	98	126	24
8/4-18	7	−1.2	− 9	9	3.8	34	.27	98	126	25
8/18-9/1	7	1.5	11	9	1.9	17	.13	98	126	28
Totals	..	....	217	..	....	541		936	1,212	758
Av. per acre	..	....	120.5	..	....	300.5		520	673	421

5. Reed canarygrass, though producing lower daily gains on lambs and ewes than smooth bromegrass, still gave satisfactory daily gains; because of a higher carrying capacity, it made satisfactory pasture.

6. On well drained organic soils, differences in lamb and ewe gains on reed canarygrass and bromegrass pastures were so small that individual farm management problems might be the most important reason for choosing one rather than the other.

CHEMICAL CONTROL OF THE EUROPEAN PINE SHOOT MOTH IN SOUTHWESTERN MICHIGAN

(A Preliminary Report)

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INSECT PESTS have been important factors in the establishment and growth of certain species of trees used for reforestation. Prior to 1950, red pine *(Pinus resinosa Ait.)* was considered to be relatively free from insect attack under Michigan conditions. However, in the past 25 years, the European pine shoot moth *(Rhyacionia buoliana Schiff.)* has become increasingly abundant and has interrupted the growth of many young red pine plantations.

Although this insect does not ordinarily cause tree death, repeated attacks can seriously deform trees and completely halt terminal growth. Since the introduction of the European pine shoot moth into the United States in 1913, it has threatened both native and ornamental pines in the northeastern United States and southeastern Canada. In Michigan, it was first recorded in 1930 by McDaniel.[1] Since this initial outbreak, the pest has gradually spread to most of the southern peninsula of Michigan where red pine is being grown.

In May 1954, county agricultural agents in all areas where concentrated European pine shoot moth infestations were known to exist were asked to send cuttings from infested plantations to the department of entomology.

Samples were received from 15 counties. The infested buds were caged and maintained at a temperature of 75 degrees Fahrenheit until complete emergence. Table 1 gives the emergence information obtained.

[1]McDaniel, E. I. (1930). European pine shoot moth found in Michigan. Mich. Agr. Expt. Sta. Quart. Bul. 13: 1-3.

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TABLE 1—European pine shoot moth emergence, 1954

County	No. of emerging adults	Emergence interval
1. Benzie	15	June 22-June 28
2. Clare	18	June 23-July 3
3. Grand Traverse	2	June 26-June 29
4. Houghton	3	July 21
5. Ingham	19	June 15-June 25
6. Ionia	11	June 18-June 26
7. Iosco	1	July 1
8. Kalamazoo	14	June 14-June 23
9. Kent	3	June 28-July 2
10. Lenawee	1	June 26
11. Macomb	5	June 18-June 23
12. Osceola	14	June 21-July 2
13. Saginaw	7	June 23-June 26
14. Washtenaw	2	June 20-June 25
15. Wexford	5	June 25-July 2

OBJECTIVE OF THE STUDY

Purpose of this study was to determine the relative length of emergence periods at various Michigan locations. Since it was impossible to rear the adults at the site of recovery, it cannot be assumed that the emergence dates listed in Table 1 would be indicative of the area where the sample was taken. The information has been used in recommending the most satisfactory period for control activities.

CONTROL MEASURES AT THE KELLOGG FOREST

The European pine shoot moth was first observed in 1951 in the Kellogg Forest in Kalamazoo County, Michigan, but damage was not serious until 1954. In 1954, a one-half acre plantation of red pine, averaging 4½ feet in height, showed a considerable number of infested tips. On June 15, 1954, when the adult moths were flying, the area was sprayed with a 3½-gallon hand sprayer.

DDT 50 percent wettable powder and Lindane 25 percent wettable powder were combined in the spray at the rate of 3 pounds of each per 100 gallons of water. All new shoots were wet with spray. Inspection in May 1955 showed almost 100 percent protection, with only one live shoot moth larva found in this small plantation.

In 1955, an adjoining plantation of about 6 acres of red pine along with six other plantations totaling 18 acres of 4-foot trees were sprayed

for shoot moth control. Two insecticides and three methods of application were used.

Check plots were not established as a part of these studies since the control measures were part of a management undertaking. The application and results are shown in Table 2.

Sprays were applied June 8, 9 and 10, 1955. Each area received one application. Adult moths were flying at this time, since the growing season was somewhat more advanced than in 1954. Sprays and dust were applied to all new growth, wetting the new shoots to the point of runoff. This required .07 gallon of spray per tree for the power sprayer and .06 gallon per tree for the hand sprayers.

The hand sprayers were 3½-gallon compressed air sprayers with an adjustable nozzle. The power sprayer was a conventional hydraulic sprayer operated at 200 pounds of pressure with a 6/64-inch nozzle opening. An 18-pound capacity, backpack, bellows-operated duster was used.

Only one area was treated with dust. The power sprayer was used on portions of three plantations, while five plantations were treated with hand sprayers. In Table 2, the percent of trees infested refers to the mean of all areas receiving similar treatment. The insect counts in October were based on resin deposits on the buds. During each sampling period, 5 groups of 10 trees were selected at random in each area sprayed, and insect counts were made.

TABLE 2—Application and results of insecticides applied at the Kellogg Forest, 1955

Insecticides	Concentration per 100 gallons of water	Method of application	Percent of trees infested	
			June 1955	October 1955
DDT—50% W.P.*.....	3 lb.	power sprayer ..	90%	37%
DDT—50% W.P.....	6 lb.	hand sprayer ...	82%	1%
DDT—5% dust.....	8 lb.	duster.....	93%	78%
DDT—50% W.P. plus.....	3 lb.	hand sprayer ...	73%	2%
Lindane—25% W.P.....	3 lb.			

*W.P.—wettable powder.

CONTROL MEASURES AT SCOTTS, MICHIGAN

At Scotts, Michigan, during 1955, five one-half acre plots of red pine averaging 7½ feet in height were treated with four different insecticides. Forty trees chosen at random from the plot area were given a preliminary examination May 17, 1955. This pre-emergence examination indicated that 100 percent of the terminal and 97 percent of the lateral buds above a height of 4 feet were infested.

Spray applications were applied when 65 percent of the moths had emerged. Heavy populations of moths were present for a 3-week period after the spray application. Application was made with a hydraulic sprayer operated at 450 pounds of pressure. About 250 gallons of spray per acre were applied until runoff occurred. The materials applied and their effectiveness are presented in Table 3.

TABLE 3—Application and results of insecticides used at Scotts, Michigan: 1955

Insecticide	Concentration per 100 gallons of water	Percent of lateral buds infested	Percent of terminal buds infested
DDT (Plot A)*	3 lb. of 50% W.P.	25	90
DDT (Plot B)	3 lb. of 50% W.P.	22	6
Endrin	1½ pt. of 19.5% Emul.	95	100
Diazinon	2 lb. of 25% W.P.	52	100
Thimet	1 gal. 48% Emul.	47	90

*This was a particularly heavy infestation

Five replications of 10 trees each were located at random in each of the one-half acre plots. Four lateral buds above a height of 4 feet, as well as a terminal bud from each tree, were examined on September 1, 1955 to determine the degree of control.

DDT was the only material which provided reasonable control under these conditions of concentrated adult populations active over a 5-week period. It was apparent that a population of this magnitude would require two applications for satisfactory control.

COST OF INSECT CONTROL

In 1955, time and cost records were kept for shoot moth and sawfly control in the Kellogg Forest. Since the cost of spraying varies directly with the size and number of trees per acre, the data are presented by number of trees of a given size. Table 4 is a summary of the cost for treating red pine 4 feet in height.

TABLE 4—Cost of applying insecticides to red pine 4 feet in height

Method of application	No. of trees treated per hour	Cost per 100 trees			
		Labor	Insecticide	Equipment	Total cost
Hand sprayer.....	110	1.14	.10	.01	1.25
Backpack duster.....	225	.55	.88	.02	1.45
Power sprayer.....	700*	.36	.11	.36	.83

*Two men, a driver, and a sprayer required; 350 trees sprayed per man hour. Insecticides applied at 3 pounds of DDT per 100 gallons of water gave 100 percent coverage.

Time spent refilling equipment is included in labor costs and in the number of trees treated per hour. The cost of insecticides used in spraying was only a small percentage of the total cost, while the cost of the material used in dusting was 61 percent of the total cost.

Dust was satisfactory for the control of sawflies but not for shoot moths. In shoot moth control on larger trees where 100 percent coverage is desirable, the hand sprayer and dust were less efficient than the power sprayer.

CONCLUSION

The European pine shoot moth has gradually spread into many red pine plantations of the southern peninsula of Michigan since discovered in the state in 1930. Studies of emerging adults indicate that the length of the emergence period, as well as the time of emergence, varies greatly throughout the state.

These studies indicate that DDT or combinations of DDT and Lindane were the most effective materials for control of this pest. The use of DDT alone was usually as effective as the DDT-Lindane combination. Sprays were more effective than dust applications.

Hand sprayers were satisfactory for the application of materials to trees under 4 feet. Hydraulic power sprayers were more effective for application of materials to trees above 4 feet in height. Four-foot trees were treated with a power sprayer for less than 1 cent per tree. Hand sprayed and dust-treated trees were protected for about 1¼ and 1½ cent per tree, respectively.

GRAIN-EQUIVALENT VALUE OF PREBUD ALFALFA HAY AND ALFALFA-RYE-GRASS SILAGE IN RESPECT TO MILK PRODUCTION

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SEVERAL EXPERIMENTS have been reviewed by Huffman et al. (1952, 1956) which have shown the superiority of immature hay and hay-crop silage for milk production. In order for the dairyman to use immature crops to the best advantage, it is important to develop new grain-feeding rules to use with these forages.

The present study was made in an attempt to determine the grain-equivalent or grain-saving value of prebud alfalfa hay and silage made from a mixture of immature alfalfa, rye and grasses.

EXPERIMENTAL

Twelve Holstein milking cows were divided into three groups of four cows each according to milk production, body weight, and stage of lactation. They were fed the following forages: mature alfalfa hay (basal hay), prebud alfalfa hay, and silage.

The experiment was set up in a three-way Latin square design during which time all groups of cows received each forage for a period of 21 days. The experiment lasted for 63 days.

FEEDS FED

The basal hay was second-cutting alfalfa, harvested in about the three-fourths bloom stage, which had been rained on during field-curing. It graded U.S. No. 2 on color and leaf. The prebud alfalfa was harvested and crushed just before bud stage and then field-cured. It contained about 5 percent dandelions, and it graded U.S. No. 1, extra

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TABLE 1—Percentage composition and coefficients of digestibility of experimental feeds

Item	Digest. trial	Matter		Ash	Protein	Ether ext.	Crude fiber	NFE†	TDN‡
		Dry	Org.						
Basal hay		88.0	82.4	5.6	14.6	1.5	29.7	36.6	47.4
Alfalfa, 2nd cut.,	1	52.0	56.1	...	64.6	−3.3	46.5	62.4	
U. S. No. 2	2	57.4	59.5	...	67.7	3.3	50.7	65.0	
	Av.....	54.7	57.8	...	66.2	0	48.6	63.7	
Experimental hay		87.0	80.0	7.0	17.6	2.2	20.2	40.0	56.7
Prebud alfalfa,	1	65.5	67.8	...	72.3	53.3	51.2	74.7	
1st cut., U. S. No. 2	2	66.7	72.2	...	74.9	53.3	52.6	75.6	
	3	68.1	71.9	...	75.5	53.3	56.1	76.1	
	4	66.5	71.2	...	74.4	56.8	52.1	75.4	
	Av.....	66.7	70.8	...	74.3	54.2	53.0	75.5	
Silage		22.5	20.9	1.6	3.0	0.85	7.7	9.4	13.0
		100.0	92.9	7.1	13.3	3.8	34.2	41.8	57.8
Alfalfa-rye-	1	64.3	....	...	67.7	30.8	70.9	61.1	
grass, 1st cut.	2	58.2	....	...	65.2	25.6	64.0	54.5	
	3	62.4	....	...	67.5	28.2	68.3	60.3	
	Av.....	61.6	....	...	66.8	28.2	67.7	58.6	
Corn, ground		88.7	87.3	1.4	9.8	4.6	3.2	69.7	76.5
	1*	....	....	...	63.0	83.0	13.0	88.0	
Botanical and chemical composition of forage cut for silage									
Alfalfa 38%.....				9.4	22.3	2.2	25.2	41.0	....
Rye 46%.....				5.4	9.2	2.5	35.2	47.9	....
Grass 14%.....				8.9	21.0	3.9	26.2	41.0	....

*Schneider's (five) coefficients of digestibility.
†Nitrogen-free extract.
‡Total digestible nutrient.

green and extra leafy when placed in the mow. Several months of storage resulted in a loss of green color which made it grade U.S. No. 2 on color when fed.

A field of immature alfalfa and brome which contained volunteer rye (Balbo) was harvested and made into silage. A randomized sample taken from the field on the day of harvest showed the following plant composition: 38 percent alfalfa, 46 percent rye, and 14 percent grasses (brome and quack). The alfalfa was in the very early bud stage (not all plants showed buds); the rye was in full bloom; and the grasses were in the preboot stage.

The crop was ensiled directly. The chemical composition of these three constituents is included in Table 1.

METHOD OF FEEDING

In order to study the grain-equivalent of the two immature forages, grain-feeding per day was decreased by 6 pounds per cow when the cows were changed from the basal hay to either of the immature forages; it was increased by 6 pounds when the cows were changed from an immature forage to the basal hay.

DATA COLLECTED

The coefficients of digestibility for the basal hay, prebud alfalfa, and silage were determined by digestion trials. The coefficients of digestibility recorded by Schneider (1947) for cows were used for the ground corn. The chemical analyses and coefficients of digestibility of the experimental feeds are presented in Table 1.

The total digestible nutrient (TDN) content of the feeds was calculated from the chemical composition and the coefficients of digestibility. In calculating the TDN content of the silage, the digestible ether extract value was not multiplied by the factor 2.25 because considerable material that is not true fat is included in this fraction.

Milk samples were saved daily from each cow; they were composited by 3-day periods and tested for butterfat. Fat-corrected milk (FCM) was determined by the usual methods. In calculating the results, all of the data are based on the last 15 days of each 21-day period. The cows were weighed once during each 3-day period. One cow in Group 3 developed acute mastitis on the basal hay ration near the end of the experiment; therefore, data for only 9 days are reported.

RESULTS AND DISCUSSION

The prebud alfalfa hay was characterized by a low crude fiber content and a high coefficient of digestibility for the nitrogen-free extract (NFE). The high coefficient may have been due, in part, to the presence of a large amount of fermentable carbohydrates (10 percent). The TDN content of the hay was 65.2 percent on the dry basis. McCullough and Sell (1955) reported that dairy cows can be maintained in high milk production on pasture alone when the digestibility of the dry matter is 70 percent or more.

The silage made from the immature alfalfa, rye, and grass was much less digestible than was anticipated according to the results obtained from digestion trials. No data appears in the literature on the TDN content of rye silage. Frear et al. (1888), however, found that green rye fed to the steers had a TDN value of 73.8 percent, on the dry basis. The rye was probably harvested when the heads were emerging, as indicated by a moisture content of 84 percent.

In setting up this experiment, the assumption was made that the alfalfa-rye-grass silage was comparable to prebud alfalfa hay, on the dry basis; but the TDN value found for the silage was only 57.8, compared to 65.2 for the prebud alfalfa. It would appear that the high rye content of the silage (46 percent) must have been responsible for the low TDN value, since the alfalfa was in the early bud stage and the grass was in the preboot stage.

The possibility that some of the nutrients could have been lost due to abnormal fermentation cannot be ignored. The mixture was ensiled without a preservative. The silage had a good aroma. The pH was 4.8.

Table 2 shows the amount of FCM produced, butterfat tests, body weights, and the feed and TDN intakes of the three groups of cows fed the three forages.

The cows in Group 1 produced 36.4 pounds of FCM on the basal hay ration and only 30.0 pounds on the silage ration. The drop in milk production was probably due to the marked decrease in the TDN intake (19.6 vs. 15.1 pounds daily). The low TDN intakes by all of the cows on the silage ration were not only due to the low TDN value of the silage, but also to low dry matter intakes. When the cows in Group 1 were changed from the silage to the prebud alfalfa hay ratio, the production of FCM again declined slightly.

Milk production decreased markedly in all of the cows in Group 2 when changed from the prebud alfalfa to the basal hay ration. This

TABLE 2—Average daily production of FCM per cow, butterfat test, body weight, and feed and TDN intakes

	Forages fed*		
	Basal hay	Prebud hay	Silage
FCM produced (lb.)			
Group 1	36.4†	29.0§	30.0‡
Group 2	32.4‡	38.7†	24.0§
Group 3	28.6§	35.1‡	32.8†
Av.	32.5	34.2	29.0
Butterfat tests (%)			
Group 1	3.0	2.9	3.1
Group 2	3.2	3.3	3.2
Group 3	3.2	3.2	3.4
Av.	3.1	3.1	3.2
Body weights (lb.)			
Group 1	1,138	1,099	1,120
Group 2	1,125	1,111	1,099
Group 3	1,143	1,134	1,148
Av.	1,135	1,115	1,123
Forage intakes (lb.)			
Group 1	24.4	26.0	89.8
Group 2	24.4	27.7	89.3
Group 3	24.6	28.4	101.0
Av.	24.5	27.4	93.4
Corn intakes (lb.)			
Group 1	10.5	4.5	4.5
Group 2	9.9	4.0	3.9
Group 3	10.2	4.0	4.0
Av.	10.2	4.2	4.1
TDN intakes (lb.)			
Group 1	19.6	18.2	15.1
Group 2	19.1	18.8	14.6
Group 3	19.5	19.2	16.2
Av.	19.4	18.7	15.3
Dry matter intakes (lb.)			
Group 1	30.7	26.6	24.2
Group 2	30.3	27.6	23.6
Group 3	30.7	28.2	26.3
Av.	30.6	27.5	24.7

*Order of feedings forages: †fed first, ‡fed second, §fed last.

drop occurred even though the amount of corn was increased 6 pounds per day per cow during the time the basal hay was fed. When the cows were changed from the basal hay to the silage ration, FCM again dropped markedly.

The production of FCM increased from 32.8 to 35.1 pounds per day when the cows in Group 3 were changed from the silage to the prebud alfalfa hay ration, and it decreased when changed from the prebud to the basal hay ration.

The cows averaged 32.5, 34.2, and 29.0 pounds of FCM per day when fed the basal hay, prebud alfalfa hay, and the silage ration, respectively. The average daily TDN intakes were 19.4, 18.7, and 15.3 pounds, respectively. During the prebud alfalfa hay periods, the cows consumed 2.9 pounds more hay and 6 pounds less corn per day than when fed the basal hay ration.

The results point out the grain-equivalent value of immature forages in comparison to ordinary hays. More FCM was produced on 0.7 pound less TDN per day per cow when the immature hay was fed. This suggests that the decrease of 6 pounds of corn daily during the prebud alfalfa feeding periods was not enough to equalize these two hays.

The results obtained from feeding the two hays show the need for new grain-feeding rules when the forage is harvested at more immature stages. These results indicate that it is wasteful to feed the same amount of grain to cows receiving immature forage as to cows receiving forage harvested in the full bloom stage, unless the cows have a superior milk production potential.

The results obtained from feeding the silage are not significant because of the markedly lower TDN intake of the cows on the silage ration. This was primarily due to the fact that the actual TDN content (57.3 percent) was much lower than was estimated. The cause of the low value is not known, unless it was due to the low feeding value of the full bloom rye. The alfalfa was cut in the early bud stage, the grass was in the preboot stage, but the rye was in full bloom. The feeding value of full bloom rye is not known.

The body weights recorded in short-time experiments do not give a true index of weight changes. The data are presented, but they do not appear to show any significant differences that can be attributed to the forages.

SUMMARY

Twelve milking cows were used in a three-way Latin square design to study the grain-equivalent of prebud alfalfa hay, alfalfa-rye-grass silage, and mature alfalfa hay. Grain-feeding per day was increased 6 pounds per cow when the cows were changed from immature hay and silage rations to the mature hay ration; it was decreased 6 pounds when cows were changed from the mature to the immature forages.

The average amounts of FCM produced per cow on the basal, prebud, and silage rations were 32.5, 34.2, and 29.0 pounds per day, respectively. The TDN intakes on the three rations were 19.4, 18.7, and 15.3 pounds per cow daily, respectively.

More FCM was produced on the prebud alfalfa hay ration with 0.7 pound less TDN intake per day than on the mature hay ration.

The results of this experiment indicate that 27.4 pounds of prebud alfalfa plus 4.2 pounds of corn were more than equal to 24.5 pounds of mature alfalfa hay plus 10.2 pounds of corn in respect to milk production.

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SOME EFFECTS OF FUNGICIDES ON THE HONEYBEE

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CHEMICALS USED TO KILL harmful insects are usually capable of killing beneficial insects also. The application of insecticides to open blossoms may be particularly destructive to pollinating bees.

Honeybees and native bees can be killed in the field from the toxic effect of poisoned nectar or water, and from poison carried into the hive mixed with pollen. Poisoned pollen has been known to kill the brood and to weaken the colony over an extended period of time. Many studies have been reported on the relative toxicity of various insecticides to honeybees.

Unfortunately, there is little reliable information available on the relative effect of insecticides on native bees or on the extent to which agricultural chemicals are reducing native bee populations. Information on the toxicity of fungicides to pollinating bees has also been lacking. The following study was initiated as a result of reports from beekeepers that some fungicides were killing bees when applied to fruit trees during bloom.

Crops dependent on insect pollination have a much greater value in the United States than the multibillion dollar damage done to crops by harmful insects. Therefore, it seems apparent that methods of safeguarding the pollinating insects can be profitably studied.

PREVIOUS STUDIES

Practically no studies have been reported on the toxicity to honeybees of the many new fungicides developed since World War II. Several earlier fungicides which were in use prior to World War II have been studied in some detail. Borchert (1930) investigated the action of commonly-used copper compounds on bees. He found the lethal dose of metallic copper to be about 9 micrograms. Herman and Brittain

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(1933) reported that, except during wet weather, it had not been found that copper fungicides killed bees under field conditions.

Hildebrand and Phillips (1935) found that copper sulfate was poisonous to bees, but that it was also repellent. Their tests did not indicate the damage to bees which might result from the application of copper sulfate to the open fruit blossoms. Shaw (1941) reported that recommended concentrations of copper sulfate killed bees, but he could not demonstrate bee mortality from copper sulfate in the orchard.

Herman and Brittain (1933) incorporated lime sulfur in sugar syrup in the dilution ordinarily used in spraying; honeybees refused to eat it. Butler (1943) also found that sugar syrup and lime sulfur was not eaten by honeybees. Carter (1943) reported that no cases of poisoning with lime sulfur had been observed in the laboratory or in the field. He recommended the use of lime sulfur as a repellent in certain arsenical sprays. Butler (1943) found that 1 percent or more of lime sulfur in spray mixtures repelled honeybees and markedly reduced mortality when added to arsenical sprays.

Davis (1916) reported that dusting colonies with sulfur killed both brood and bees. Herman and Brittain (1933) found that applying sulfur dust to blossoms resulted in pronounced dysentery in honeybees. Shaw (1941) found that wettable sulfur dusted on brood combs killed some brood and eggs. Preliminary tests by Shaw and Bourne (1942) indicated that sulfur dust applied to fruit trees in bloom repelled honeybees. This poses the problem of the extent to which such an application would impede pollination.

Butler (1943) reported that syrup containing flowers of sulfur was eaten readily by bees. Little evidence of poisoning was observed until after 6 hours. After 12 hours, bees died in rapidly increasing numbers. Thurston (1956) pointed out that some fungicides may have adjuvant action when combined with insecticides. Further study may indicate that some of the apparent adjuvant action is due to independent insecticidal action of the fungicide.

Shaw (1952) reported that the phenyl mercury compound (Puratized) did not kill bees exposed to contact action or bees exposed for 20 minutes to dried residue. Both tests were carried out in sleeve cages in an orchard. No repellent action was observed.

METHODS AND RESULTS

The toxicity to honeybees of 14 fungicides listed in Table 1 was studied: (a) by feeding in small cages; (b) by spraying bees in cages

TABLE 1—Fungicides tested for toxicity to honeybees

Common name	Chemical name	Trade name
organic mercury...	Phenyl mercury acetate.....	Puratized apple spray
organic mercury...	Phenyl mercury acetate.....	Tag 331
organic mercury...	N-phenylmercuri-ethylenediamine.....	Coromerc
organic mercury...	Phenylmercuric acetate.....	Phix
glyodin.....	2-heptadecyl-glyoxalidine.....	Crag Fruit Fungicide 341
ziram.....	Zinc dimethyl-dithiocarbamate.....	Zerlate
ferbam.....	Ferric dimethyl-dithiocarbamate.....	Fermate
no common name..	Sodium dimethyl-dithiocarbamate.....	Coro SDD
maneb.....	Manganous ethylene bisdithiocarbamate.	Manzate
dichlone.....	2,3-dichloro-1,4-naphthoquinone.....	Phygon
no common name..	Copper zinc chromate.....	Crag 658
captan.....	N-(trichloromethyl mercapto)..... 4-cychlohexene-1,2-dicarboximide.....	Orthocide
zineb.....	Zinc ethylene-bisdithiocarbamate.....	Dithane Z-78
thiram.....	Tetramethylthiuram disulfide.....	Pomasol

for contact effect; and (c) by spraying nectar plants in field cages. In addition, the median lethal dose of Puratized apple spray was determined.

FEEDING BEES IN SMALL CAGES

Bees were shaken from combs into screened wooden cages 5 inches by 5 inches by 5 inches. Two sliding bottom boards were designed to

Fig. 1. Bees being shaken directly into wire-screened cages.

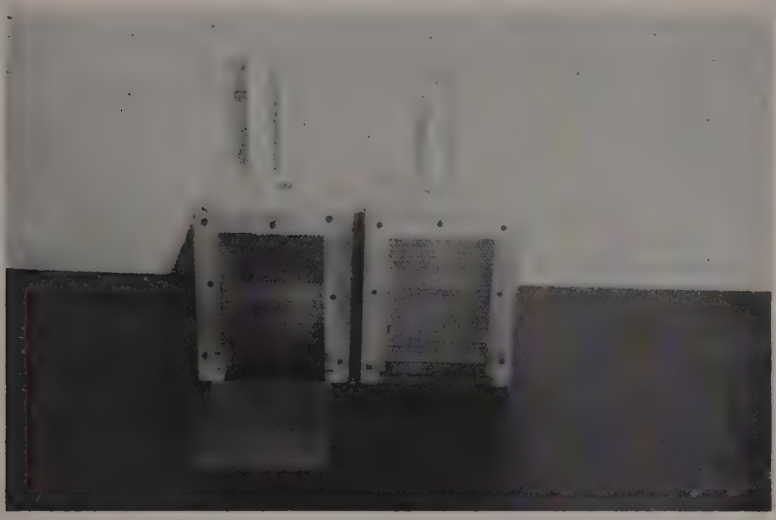

Fig. 2. Cages and inverted vials used in feeding trials.

facilitate filling the cages, counting, and removing the dead bees daily (Figs. 1 and 2). All 14 of the fungicides were fed to bees in these cages. The materials were fed directly to the bees in a 20-percent sugar syrup by using inverted vials, covered at one end with wax paper as described by Eckert (1949).

Trials were repeated 10 times for the first eight fungicides shown in Table 2. They were repeated five times for the remaining six fungicides which appeared slightly toxic or nontoxic in the early trials. The fungicide-syrup was replaced every few days to prevent spoilage, and the wax paper was replaced to prevent leaking. Bees were considered dead if they were unable to move, and mortality counts were taken at least once daily. The cages were kept at a room temperature of about 74° F.

Results

Relative toxicity to honeybees of the 14 fungicides used in the small-cage feeding trials is shown in Table 2. Note that Dithane Z-78 sustained bee life well beyond the check in these trials.

SPRAYING CAGED BEES FOR CONTACT EFFECT

The contact effect of fungicides on honeybees was tested by spraying bees held in cages. From 50 to 100 bees were shaken from combs

*TABLE 2—Average results of small-cage feeding trials**

Fungicide	No. of bees	Hours required for 50% mortality	Hours required for 100% mortality
Puratized	137.9	21.7†	46.7
Tag 331	183.2	22.7†	67.9
Crag 341	128.2	44.1†	102.0
Phix	151.5	67.6†	170.6
Coromerc	168.6	94.4†	239.0
Coro SDD	181.6	97.1†	198.2
Crag 658	144.2	146.4†	907.2
Zerlate	95.0	278.4‡	609.6
Pomasol	113.0	292.8‡	978.0
Manzate	150.6	250.8‡	840.0
Phygon	183.5	208.8‡	643.2
Fermate	235.6	290.4‡	796.8
Orthocide	108.1	422.0‡	756.4
Dithane Z-78	210.0	648.0	1,200.0
Check	173.6	279.2‡	726.4

*Statistical treatment through cooperation of statistics department, Michigan State University.
†A significant decrease in hours at the 1 percent level.
‡No significant variation from the check.

into cylindrical wire-screened cages 2 inches in diameter and 5 inches long. Trials were replicated twice. The fungicides were sprayed through the cages in a DeVilbiss spray chamber (Fig. 3). The spray solutions were kept constantly mixed and were applied at 30 pounds pressure with an atomizer-type spray gun.

The cages were placed about 2 feet in front of the spray gun and turned slowly by hand until runoff occurred. This took about 10 seconds. Cages of "check" bees were sprayed with tap water for comparison with the fungicide-treated bees. After spraying, the bees were removed and placed in 5-inch by 5-inch by 5-inch holding cages and fed a 20 percent sugar syrup. Mortality was recorded each day.

Results

Relative toxicity to honeybees of the 14 fungicides used in the contact trials is shown in Table 3. For both trials, the 50 percent mortality column is considered to be more indicative of the relative toxicities of the fungicides than the 100 percent mortality column. This may be due to the fact that some bees escape effective contact with the spray.

SPRAYING NECTAR PLANTS IN FIELD CAGES

During the summer of 1954, five 4-foot by 6-foot by 6-foot wire-screened cages (Fig. 4) were set up in an alfalfa field. After two trials,

Fig. 3. Spraying bees for contact effect in a DeVilbiss spray chamber.

TABLE 3—Averaged contact effect of fungicides on honeybees

Fungicide	No. of bees	Hours required for 50% mortality	Hours required for 70% mortality	Hours required for 100% mortality
Puratized	98	33*	150	516
Tag 331	85	89†	174	552
Crag Fruit Fungicide 341	104	77‡	114	516
Zerlate	100	51*	86	228
Coro SDD	88	57*	88	163
Pomasol	99	192§	276	588
Dithane Z-78	144	156†	210	396
Crag 658	92	216§	246	480
Phix	96	396§	444	1,020
Coromerc	76	186§	224	384
Manzate	100	203§	233	408
Fermate	91	228§	265	792
Phygon	87	212§	248	432
Orthocide	76	300§	347	576
Check	120	270§	302	492

*Indicates a significant decrease in hours at the 1 percent level.
†Indicates no significance.
‡Indicates a significant decrease in hours at the 5 percent level.
§Indicates no significant variation from the check.

they were moved to a field of buckwheat for two more trials. Each cage was provided with a two-frame nucleus of about 1,500 bees and a queen. The plants in each cage were sprayed with fungicide at the recommended concentration and at an estimated rate of 200 gallons per acre.

In 1955, 15 cages were set up in an alfalfa field. The cages were moved to new areas in the field for each trial.

Results

It appears that the problem of providing identically controlled nuclei colonies and cage conditions may account for the different results in the 1954 and 1955 field-cage tests. Although results were too variable to apply statistical analysis, they did indicate that bees were killed by some fungicides applied to plants on which the bees were feeding.

MEDIAN LETHAL DOSE OF PURATIZED TO THE HONEYBEE

Tests were carried out to determine the median lethal dose of Puratized, because it was found to be the most toxic to honeybees of the fungicides tested. The method used was similar to that described by Eckert (1949). Specific amounts of fungicide were fed from micropipettes to individual bees in queen-mailing cages. The micropipettes were placed at an angle of 30 degrees from the horizontal (Fig. 5).

The fungicides were dissolved in a 20 percent sugar syrup made with distilled water. Bees were held in cages without food for 3 to 4

Fig. 4. Wire-screened cages, each containing a small colony of bees, used for field trials.

Fig. 5. Micropipettes used to feed individual bees in small cages to determine median lethal dose.

hours; as a result, they consumed the total amount of fungicide syrup under test at one feeding.

The number of hours required for 50 percent mortality was recorded for 60 individually-fed bees for 25 micrograms of fungicide. Groups of 100 individually-fed bees were tested on 37.5 micrograms, 50 micrograms, and a check of sugar syrup each. A wax cup in each cage was then filled with 20 percent sugar syrup as a further food supply.

Results

Length of life of bees fed 25 micrograms was comparable to the check. Fifty percent of the bees fed 37.5 micrograms of Puratized died in an averaged time of 71.1 hours. Fifty percent of the bees fed 50 micrograms of Puratized died in an averaged time of 22.7 hours. Fifty percent of the bees in check cages died in an averaged time of 111.3 hours.

These tests indicate that, if 24 hours is taken as a standard time, the median lethal dose (m.l.d.) of Puratized is about 50 micrograms. If 72 hours is taken as a standard time, the m.l.d. of Puratized is about 37.5 micrograms.

DISCUSSION

The above tests point out that some of the currently-used fungicides are toxic to bees under the conditions described. A more comprehensive assessment of the toxicity of specific fungicides to specific species of pollinating bees, under orchard and field conditions, awaits completion of further study. Honeybees were killed by some fungicides in the laboratory and under simulated field conditions in field cages. Beekeepers have also reported bees killed when organic mercury fungicides have been sprayed on fruit trees in bloom.

The application of poisons to plants during full bloom may result in much more than monetary loss to beekeepers. The nests of many species of native bees may be exterminated if overwintered females are killed early in the season. Over a period of years, populations of valuable native pollinators may be seriously reduced or even completely wiped out in areas where their nectar and pollen supply contains toxic materials. If spray materials kill off the field force in honeybee colonies, or if pollen-containing toxic material is stored in the hive and continues to kill brood over an extended period of time, the beekeeper's honey crop (and profits) may be seriously reduced.

In view of the need to conserve pollinating bees and the evidence of the toxicity of some fungicides to honeybees, it seems advisable to suggest caution in the use of some fungicides on trees or other plants in bloom.

The following commonly suggested practices for the use of insecticides might well be adopted when using fungicides most poisonous to bees.

(1) Do not apply a spray poisonous to bees when trees or plants are in bloom.

(2) Mow or otherwise destroy dandelions or other flowering orchard cover that might become a hazard to bees after spraying.

(3) Avoid leaving puddles when spray equipment is emptied or cleaned.

(4) Notify the beekeeper if his bees are in danger.

(5) Spray in the evening after bees have returned to the hives.

(6) Apply dusts only when the air is still to lessen drift to blossoms in nearby fields.

SUMMARY

Fourteen fungicides often used in orchards were tested for toxicity to the honeybee. Laboratory feeding trials indicated that Puratized and Tag 331 were quite toxic, killing 50 percent of the bees within 1 day. Crag Fruit Fungicide 341 was toxic to 50 percent of the bees within 2 days; Phix, Coromerc, and Coro SDD were moderately toxic, killing 50 percent of the bees in from 3 to 4 days. Zerlate, Pomasol, Manzate, Fermate, Phygon, Crag 658, and Orthocide were slightly toxic or nontoxic, and Dithane Z-78 appeared to extend the life of the bee somewhat.

In tests for contact effects to the honeybee, Puratized killed 50 percent of the bees within 2 days. Tag 331, Crag Fruit Fungicide 341, Zerlate, and Coro SDD killed 50 percent within 4 days. Pomasol, Dithane Z-78, Crag 658, Coromerc, Phix, Manzate, Fermate, Phygon, and Orthocide had no contact effect.

Field-cage tests on alfalfa and buckwheat in 1954 and 1955 again indicated that Puratized and Tag 331 were poisonous to honeybees. Crag 341 appeared to be less toxic than in the small-cage tests. Phix and Coromerc displayed moderate toxicity. Orthocide, Phygon and Manzate appeared to be toxic in field-cage tests, although they were relatively nontoxic in other feeding tests (it is possible that some unknown factor other than toxicity caused the high mortality).

The remaining fungicides showed slight or no toxicity. The median lethal dose for Puratized was 50 micrograms within 24 hours and 37.5 micrograms within 72 hours.

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EFFECT OF VARIOUS WAVELENGTHS OF LIGHT ON SELECTED ORNAMENTAL PLANTS

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MOST OF THE RESEARCH studying the effects of supplemental artificial light on plants has been limited to florist crops. Response of plants to increased day length have been reported as earlier maturation, greater flower production, increased stem length, and increased number of flowering stems (Poesch, 1935; Post, 1942; Withrow and Withrow, 1947; Laurie, 1930; Piringer and Stuart, 1955; and Vince, 1956). Additional illumination may retard flowering, delay flower bud development, or change the type of flowers produced (Laurie, 1930; Holdson and Laurie, 1951; and Cooper and Watson, 1952).

Growth responses of selected plant materials exposed to supplementary illumination of various wavelengths were studied to compare linear growth and flower production with plants grown under daylight.

MATERIALS AND METHODS

In September 1954, mixed seedlings of *Zinnia elegans,* rooted cuttings of *Chrysanthemum morifolium* cultivar Indianapolis White and Yellow, rooted cuttings of *Pelargonium hortorum* cultivar Scarlet Princess, *Spiraea vanhouttei, Euonymus vegetus, Juniperus chinensis columnaris* and *Taxus media hicksii* were potted and grown in a greenhouse with a night temperature of 60° F.

These plants were grouped in six plots; five received additional artificial light from four 100-watt incandescent lamps of blue, green, red, white, and yellow suspended 30 inches above the plants. Additional light was given the test plants between the hours of 5 and 12 p.m.

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The wavelength transmissions of these colored incandescent lamps shown in Tables 1 and 2 were obtained by using a Bausch and Lomb spectroscope.

With the exception of those plants receiving additional illumination from the white lamps, all *Zinnia elegans* produced more stem length than plants that received no supplementary light (Table 1). As shown in Table 2, the plants which received only daylight produced about twice as many flowers as the plants receiving supplementary light. The red source of light had the greatest stimulatory effect upon flower production.

Highly significant linear growth increases resulted on *Chrysanthemum morifolium* when the plants received additional light from the various light sources. As seen in Table 1, no one wavelength was superior to any other in the production of this growth. The use of additional light of all wavelengths stimulated vegetative growth, and the plants under natural photoperiod flowered on short stems.

Euonymus vegetus plants exposed to red illumination produced significantly more shoots than the other lighted plants, although there was an average of three shoots less than produced by the unlighted plants. All plants grown under longer photoperiods had reduced total length, except that those plants exposed to the red source of light produced an average of 2.2 inches more linear growth than the unlighted test plants (Table 1).

Total flower production of *Pelargonium hortorum* increased when the plants were grown with blue, red, and white light as compared to those which received normal day length (Table 2). All Pelargonium plants grown under additional light produced longer flower stems.

TABLE 1—Linear growth responses of selected ornamental plants to various wavelengths of light (average of five plants: inches)

Plants	Wavelengths of light in Angstrom Units						LSD*	
	Blue 4100-7600	White 4250-7600	Green 4650-7150	Yellow 5100-7250	Red 6000-7400	Natural Light	.05	.01
Zinnia elegans.....	14.96	9.55	18.14	14.13	16.14	12.13	5.99	8.02
Chrysanthemum morifolium.....	7.20	6.80	6.46	6.14	6.60	3.88	1.84	2.51
Euonymus vegetus.	3.85	2.63	3.38	3.20	6.43	4.23	3.78	NS†
Taxus media hicksii	2.50	2.30	2.88	2.10	2.14	2.74	NS	NS
Juniperus chinensis columnaris.....	19.0	....	16.00	14.3	21.50	15.00	NS	NS
Spiraea vanhouttei.	11.52	12.20	12.88	11.92	11.74	10.82	NS	NS

*Least significant difference.
†Not significant.

TABLE 2—Flower production of Zinnia elegans and Pelargonium hortorum as influenced by various wavelengths of light (average of five plants)

Plants	Wavelengths of light in Angstrom Units						LSD*	
	Blue 4100-7600	White 4250-7600	Green 4650-7150	Yellow 5100-7250	Red 6000-7400	Natural Light	.05	.01
Zinnia elegans.....	1.75	1.63	1.75	1.88	2.25	3.13	1.22	NS†
Pelargonium hortorum.....	22.80	18.80	13.80	15.80	20.60	18.60	NS	NS

*Least significant difference.
†Not significant.

These findings are contrary to those of Post (1942) who reported Pelargonium unresponsive to changes of day length.

Plants exposed to longer day lengths averaged 9.4 inches greater height than those receiving no supplemental light. This response was especially shown by plants grown under red light; these had an average of 21.8 inches greater height than the unlighted. Vince (1956) noticed increased stem and internode length of Lycopersicon species with increases in light wavelengths.

In general, growth of *Taxus media hicksii* was slightly inhibited by additional illumination (Table 1) with the exception of plants grown under the green source of light, although growth was not significantly greater than the unlighted plants. The red and yellow sources of illumination had the greatest inhibiting effect on growth.

Data in Table 1 show further that *Juniperus chinensis columnaris* responded to supplementary light of blue, green, and red sources with increased growth. The greatest response was shown for those under red illumination, averaging 6.5 inches more growth than the unlighted plants.

Spiraea vanhouttei grown under additional light had more linear growth than those receiving normal day length. Plants exposed to the green and white sources of light were the most influenced, averaging 1.7 inches more growth than those with no additional illumination.

SUMMARY

Growth responses of selected plant materials exposed to supplemental illumination of various wavelengths was observed.

All plants were exposed to additional light of blue, green, red, white, and yellow wavelengths for 1 year in a greenhouse with a night temperature of 60°F.

Zinnia elegans produced greater linear growth when exposed to supplementary light, while those grown with normal day length produced the most flowers. The lighted *Chrysanthemum morifolium* plants had greater linear growth but reduced flowering. Additional light inhibited new shoot development and total stem elongation of *Euonymus vegetus*. *Pelargonium hortorum* plants produced more flowers on longer flower stems and greater plant height when grown under supplementary illumination. Growth of *Taxus media hicksii* was slightly inhibited; growth of *Juniperus chinensis columnaris* was greatly increased by additional light. Supplementary illumination uniformly increased linear growth of *Spiraea vanhouttei*.

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THE PHYTOTOXICITY OF INSECTICIDE FORMULATIONS UTILIZED AS IN-ROW TREATMENTS OF ONIONS AND RADISHES

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PHYTOTOXICITY has been a serious problem with many organic insecticide formulations. Symptoms include poor stands, retarded growth, delayed emergence, and necrotic lesions on the foliage.

Various workers have reported on the phytotoxic effects of insecticides, both under laboratory conditions (Casida and Allen, 1951) and in the field (Crowell and Morrison, 1950; Stitt and Evanson, 1949). In Michigan, poor stands have resulted when certain formulations were used as in-row treatments on onions, radishes, and other row crops (Merrill, 1953). Certain granular insecticide formulations applied to corn foliage caused serious "burning" of the foliage where the granules collected on the plant.

The purpose of this investigation was to evaluate the various phytotoxicity symptoms and to determine which constituents of the formulation caused the damage.

PROCEDURE

Onion and radish seeds were planted in the greenhouse at the rate of 30 seeds per foot of row in flats filled with sterilized potting soil. The temperature was maintained between 75° and 80° F. Heptachlor formulations were applied at the rate of 30 and 60 pounds of the formulation per acre on onions and 120 pounds on radishes. Dieldrin formulations were applied at the rate of 30 pounds per acre.[1]

The rates were based on 31,950 linear feet of row per acre. In each test, the treatments were randomized and replicated four times. A

[1]Acknowledgment is extended to the Velsicol Chemical Corporation and the Shell Chemical Corporation for their cooperation in formulating the materials.

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TABLE 1—The effects of in-row treatment on the emergence of onion seeds

Formulation				Mean emergence per 25 seeds		
Toxicant	Carrier	Solvent	Deacti-vator	Test I (30 lb./acre)*	Test II (60 lb./acre)	Test III (60 lb./acre)
1. Heptachlor 2½%	Attaclay 30/60 mesh...	Hexane (solvent removed)† ..	"H" 8%	22.2	17.4	18.2
2. Heptachlor 2½%	Attaclay 30/60 mesh...	Deobase 30%.....	"H" 8%	15.2	9.8	9.0
3. Heptachlor 2½%	Attaclay 30/60 mesh...	AR-55, 30%.....	"H" 8%	7.0	0.6	3.0
4. Heptachlor 2½%	Vermiculite No. 4.....	Hexane (solvent removed)...	"H" 3%	21.7	20.8	23.4
5. Heptachlor 2½%	Vermiculite No. 4.....	Deobase 30%.....	"H" 3%	22.5	17.6	21.0
6. Heptachlor 2½%	Vermiculite No. 4.....	AR-55, 30%.....	"H" 3%	20.7	10.0	12.0
7.	Vermiculite No. 4.....	.....	"H" 3%	22.0	21.2	20.4
8.	Attaclay 30/60 mesh...	.....	"H" 8%	22.2	19.8	21.6
9. Heptachlor 2½%	Attaclay 30/60 mesh...	Hexane (solvent removed)...	....	10.5	13.8	10.2
10. Heptachlor 2½%	Attaclay 30/60 mesh...	Deobase 30%.....	....	5.7	5.2	4.0
11. Heptachlor 2½%	Attaclay 30/60 mesh...	AR-55, 30%.....	....	8.0	1.8	1.8
12. Heptachlor 2½%	Vermiculite No. 4.....	Hexane (solvent removed)...	....	21.5	17.0	20.4
13. Heptachlor 2½%	Vermiculite No. 4.....	Deobase 30%.....	....	21.0	16.6	21.2
14. Heptachlor 2½%	Vermiculite No. 4.....	AR-55, 30%.....	....	21.5	10.0	14.4
15.	Attaclay 30/60 mesh...	.....	....	21.5	21.2	22.0
16.	Vermiculite No. 4.....	.....	....	21.5	19.8	21.4
17.	Attaclay 30/60 mesh...	Hexane (solvent removed)...	....	....	....	20.8
18.	Vermiculite No. 4.....	Hexane (solvent removed)...	....	....	....	22.4
19.	Attaclay 30/60 mesh...	Deobase 30%.....	....	....	....	10.0
20.	Vermiculite No. 4.....	Deobase 30%.....	....	....	....	20.6
21.	Attaclay 30/60 mesh...	AR-55, 30%.....	....	....	....	3.8
22.	Vermiculite No. 4.....	AR-55, 30%.....	....	....	....	15.0

23. Heptachlor 2½%	Vermiculite No. 4.....	Deobase 30%.....	"H" 3%	....	....	21.6
24. Heptachlor 2½%	Vermiculite No. 4.....	Deobase 10%.....	"H" 3%	....	....	20.4
25. Heptachlor 2½%	Vermiculite No. 4.....	Deobase 5%.....	"H" 3%	....	....	19.8
26. Heptachlor 2½%	Attaclay 30/60 mesh...	Deobase 30%.....	"H" 8%	....	....	4.6
27. Heptachlor 2½%	Attaclay 30/60 mesh...	Deobase 10%.....	"H" 8%	....	....	7.2
28. Heptachlor 2½%	Attaclay 30/60 mesh...	Deobase 5%.....	"H" 8%	....	....	8.4
29. Heptachlor 2½%	Vermiculite No. 4.....	AR-55, 30%.....	"H" 3%	....	....	21.4
30. Heptachlor 2½%	Vermiculite No. 4.....	AR-55, 10%.....	"H" 3%	....	....	20.2
31. Heptachlor 2½%	Vermiculite No. 4.....	AR-55, 5%.....	"H" 3%	....	....	21.2
32. Heptachlor 2½%	Attaclay 30/60 mesh...	AR-55, 30%.....	"H" 8%	....	....	8.8
33. Heptachlor 2½%	Attaclay 30/60 mesh...	AR-55, 10%.....	"H" 8%	....	....	8.4
34. Heptachlor 2½%	Attaclay 30/60 mesh...	AR-55, 5%.....	"H" 8%	....	....	7.4
35. Check‡.....	.....	.....	....	22.0	19.2	21.0
			LSD 5%	3.4	4.2	2.79
			LSD 1%	4.6	5.6	3.69

*Weight of formulation.
†After formulation, hexane was removed by vacuum stripping.
‡Seed only.

funnel type distribution device was constructed to apply the material in contact with the seed. This is the same type of application that is used commercially for maggot control in onions in Michigan. Stand counts were made when the onions were in the loop stage and when the first true leaves appeared on the radishes.

The study was originally established to evaluate the 16 formulations outlined in Table 1 and the first 16 heptachlor formulations in Table 2. After the results from initial studies with these formulations were reviewed, the additional 18 formulations included in Table 1 were tested. This will explain why duplicate formulations appear in Table 1.

DISCUSSION OF RESULTS

In reviewing the emergence data in Tables 1, 2, and 3, it is apparent that the carriers (both attaclay and vermiculite), and the deactivators did not cause phytotoxicity when applied in direct contact with the seed.

There were indications in the tests that both deactivator "H" and urea acted as safening agents. The increase in emergence when the deactivators were present was not always of sufficient degree to be

TABLE 2—The effects of in-row treatment on the emergence of radish seeds

Formulation				Mean emergence per 25 seeds
Toxicant	Carrier	Solvent	Deacti-vator	Rate* 120 lb./acre
1. Heptachlor 2½%	Attaclay 30/60 mesh...	Hexane (solvent removed)† ..	"H" 8%	23.2
2. Heptachlor 2½%	Attaclay 30/60 mesh...	Deobase 30%.....	"H" 8%	22.0
3. Heptachlor 2½%	Attaclay 30/60 mesh...	AR-55, 30%.....	"H" 8%	13.5
4. Heptachlor 2½%	Vermiculite No. 4.....	Hexane (solvent removed)...	"H" 3%	23.7
5. Heptachlor 2½%	Vermiculite No. 4.....	Deobase 30%.....	"H" 3%	23.0
6. Heptachlor 2½%	Vermiculite No. 4.....	AR-55, 30%.....	"H" 3%	14.2
7.	Vermiculite No. 4.....	.....	"H" 3%	24.0
8.	Attaclay 30/60 mesh...	.....	"H" 8%	23.5
9. Heptachlor 2½%	Attaclay 30/60 mesh...	Hexane (solvent removed)...	....	21.7
10. Heptachlor 2½%	Attaclay 30/60 mesh...	Deobase 30%.....	....	20.2
11. Heptachlor 2½%	Attaclay 30/60 mesh...	AR-55, 30%.....	....	18.7
12. Heptachlor 2½%	Vermiculite No. 4.....	Hexane (solvent removed)...	....	24.2
13. Heptachlor 2½%	Vermiculite No. 4.....	Deobase 30%.....	....	20.7
14. Heptachlor 2½%	Vermiculite No. 4.....	AR-55, 30%.....	....	13.5
15.	Attaclay 30/60 mesh...	.....	....	24.7
16.	Vermiculite No. 4.....	.....	....	24.0
17. Check‡.....	.....	.....	....	23.0
			LSD 5%	3.5
			LSD 1%	4.7

*Weight of formulation.
†After formulation, hexane was removed by vacuum stripping.
‡Seed only.

TABLE 3—The effects of in-row treatment on the emergence of onion seeds

Formulation				Mean emergence per 25 seeds
Toxicant	Carrier	Solvent	Deacti-vator	Rate 30 lb./acre*
1. Dieldrin 10%	Attaclay 30/40 mesh...	Methyl ethyl ketone.....	UREA	20.0
2. Dieldrin 10%	Attaclay 30/40 mesh...	Humble heavy aromatic naphtha.	UREA	18.3
3. Dieldrin 10%	Attaclay 30/40 mesh...	Shell HI-605 (mineral seal oil)...	UREA	11.6
4. Dieldrin 10%	Attaclay 30/40 mesh...	Shell HI-647 (dormant heavy oil)	UREA	8.3
5. Dieldrin 10%	Attaclay 30/40 mesh...	Empire kerosene.....	UREA	18.6
6. Dieldrin 10%	Attaclay 30/40 mesh...	Shell dieseline.....	UREA	5.3
7. Dieldrin 10%	Attaclay 30/40 mesh...	Shell dieseline.....	.....	3.0
8. Dieldrin 10%	Attaclay 30/40 mesh...	Carter heavy aromatic naphtha ..	.....	8.0
9.	Attaclay 30/40 mesh...	.....	.....	22.3
10. Dieldrin 10%	Vermiculite No. 4.....	Methyl ethyl ketone.....	UREA	19.3
11. Dieldrin 10%	Vermiculite No. 4.....	Carter heavy aromatic naphtha..	UREA	21.0
12. Dieldrin 10%	Vermiculite No. 4.....	Shell HI-605 (mineral seal oil)...	UREA	18.6
13. Dieldrin 10%	Vermiculite No. 4.....	Shell HI-647 (dormant heavy oil)	UREA	18.0
14. Dieldrin 10%	Vermiculite No. 4.....	Empire kerosene.....	UREA	19.3
15. Dieldrin 10%	Vermiculite No. 4.....	Shell dieseline.....	UREA	19.0
16. Dieldrin 10%	Vermiculite No. 4.....	Shell dieseline.....	.....	14.3
17. Dieldrin 10%	Vermiculite No. 4.....	Carter heavy aromatic naphtha...	.....	17.3
18.	Vermiculite No. 4.....	.....	.....	19.0
19. Check†	.....	.....	.....	22.3
		LSD 5%.....	.....	5.68
		LSD 1%.....	.....	7.58

*Weight of formulation.
†Seed only.

statistically significant, but emergence was consistently increased in all replications where phytotoxicity was present.

The phytotoxicity problem appeared to be directly associated with the type and amount of solvent used in the formulation. In their evaluation of various solvents, Gast and Early (1956) found many solvents to be highly toxic to certain plant foliage. In the heptachlor formulations, deobase and AR-55 were the solvents which were responsible for most of the serious depression in seedling emergence. Generally, AR-55 was slightly more phytotoxic than deobase.

When hexane was used as a solvent, the hexane was removed from the finished formulation by vacuum stripping. The poor emergence of seedlings treated with formulation 9 (Table 1) would indicate that possibly some of the hexane remained on the granule. When the amount of deobase and AR-55 was increased from 5 to 30 percent, there generally was not a corresponding decrease in seedling emergence.

Many of the experimental and commercial granulated formulations used in 1954 contained quantities of solvents comparable with the higher concentrations tested in this study.

In the dieldrin formulations, Shell HI-605, HI-647, dieseline, and Carter heavy aromatic naphtha all significantly reduced onion emergence. Methyl ethyl ketone, Humble heavy aromatic naphtha, and Empire kerosene combined with urea did not significantly lower seedling emergence.

When phytotoxic formulations were applied to both attaclay and vermiculite, germination was consistently less depressed than when the vermiculite carrier was used. This occurred with both the heptachlor and dieldrin formulations.

There was no indication that the toxicants, either heptachlor or dieldrin, inhibited emergence when the formulations were applied at the rate of 30 pounds on onions and 120 pounds on radishes. The radish seedlings reacted similarly to the onions in response to solvents and the effect of carriers. Radishes were the one exception; they were much more tolerant than onions, and the variations in emergence were slight.

SUMMARY AND CONCLUSION

In-row treatments of granulated insecticide formulations were applied to onion and radish seeds in the greenhouse. The emergence of the seedlings was used as the criteria for evaluating the relative phytotoxicity of the various formulations.

The results indicate that:

1. The carriers and deactivators did not cause phytotoxicity when applied in direct contact with the seed.
2. Generally, there was an indication that the deactivators acted as a safening agent when they were included in the phytotoxic formulations.
3. The severity of injury appeared to be directly associated with the type and quantity of solvent used.
4. There was consistently less injury when comparable phytotoxic materials were formulated on the vermiculite in contrast to the attaclay carrier.
5. The radish seedlings were consistently more tolerant than onions of the injurious formulation.

On the basis of these results, it would appear that the phytotoxicity problems associated with granulated formulations of insecticides could be greatly reduced by careful consideration of the solvents and other constituents of the formulation.

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FIELD KEY-PUNCHING AND MARK-SENSING OF FORESTRY RESEARCH DATA

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DEPARTMENT OF FORESTRY

IBM AND SIMILAR electric tabulating machine techniques were first used in forestry 25 or 30 years ago. Use of these methods has increased greatly in the past decade. Punched-card methods are now widely used in forest resource inventories and in forest management operations by both private and public forest landowning organizations.

Many of the punched-card techniques have been adapted to forestry research activities. Compiling and analyzing voluminous data used to be tedious and time-consuming; now it is handled easily and accurately.

Two punch-card methods are used in forestry research. In one, field observations and measurements are recorded on a form, tally sheet, or similar document in a routine manner. Later, the data are transferred by the operator of an electric key-punch machine into the IBM tabulating cards. Accuracy is checked by a verification process which consists essentially of repeating the key-punching of the same cards, thus locating and correcting errors made by the first key-punch operator.

When the cards have been key-punched and verified, they are ready for compilation, computation, or analysis as required by the problem at hand. This procedure is very well described by Wheeler (1935).

The other widely-used procedure in forestry applications of punched-card methods is that of mark-sensing the tabulating cards in the field when the observations and measurements are made. Marks with a soft-leaded pencil are made on the cards in appropriate spaces. Later, the cards are processed by the Reproducing Gang-Punch.

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Equipped with a mark-sensing feature, it senses electrically the pencil marks on the cards and punches the data into them. The cards are then ready for compilation or tabulation in the usual manner. This procedure is described in detail by Wright (1954).

A possible additional procedure is to key-punch the data into the cards directly at the location and at the time the observations and measurements are being made. A portable, manually-operated key-punch machine is used in this procedure.

STUDY MADE AT M.S.U.

To explore the possibilities of field key-punching technique for forest research and inventory purposes, and to compare some of its aspects with mark-sensing and the ordinary listing procedures, a small-scale study was made on three 2-acre plots located in Baker Woodlot on the Michigan State University Campus. All trees 3.5 inches d.b.h. and larger were numbered beforehand, and breast height was indicated with a paint mark.

Three methods were assigned to the three plots in a random manner, and then the complete inventory process was performed, starting with the field measurements and continuing all the way through a summary stand and stock table for each plot.

The information recorded for each tree consisted of the following:

1. Tree number.
2. Species.
3. D.b.h. to the nearest tenth-inch.
4. Merchantable height in 16-foot logs to the nearest half-log.
5. Form class (by ocular estimate).
6. Crown class, by the four standard crown classes (dominant, codominant, intermediate and suppressed).
7. Vigor class, according to the four vigor classes used in classifying northern hardwoods (Goetzen et al., 1943).
8. Grade of the butt log, by the four log grades used in grading northern hardwood logs (U.S. Forest Service, 1949).
9. Cull defect class, based on six cull defect classes as developed by the U.S. Forest Service (Zillgitt and Gevorkiantz, 1946).

For trees less than 9.5 inches d.b.h., only tree number, species and d.b.h. were recorded. A cruiser and a tallyman made up the two-man field crew for all three methods.

TALLY LISTING

For the first method, ordinary cruising procedure was used, and data were listed in the usual manner. The tally sheets were prepared in the office, and the data were recorded as field measurements were made. From this listing, a stand and stock table per acre for the plot was compiled, showing the number of trees, volume, and basal area by d.b.h class for each species. This procedure of manually grouping and tabulating the data might be termed a "longhand" method.

On a per acre basis, the stand and stock table shows there were 190 trees and 116.85 square feet of basal area; gross and net volumes were 13,368 and 12,100 board-feet, respectively. Time and cost data for this procedure are summarized in Table 1, along with similar data for the other two methods.

MARK-SENSING

In the second method, IBM mark-sensing cards were taken into the field and the data for the plot recorded on them by the mark-sensing procedure. The data recorded on each card was verified by a sight-check as the work progressed. The plot number, basal area and gross volume for each tree were mark-sensed on the cards in the office following completion of the field procedure.

The mark-sensed cards were then sent through the mark-sense punching machine to be converted into key-punched cards. Any cards mark-sensed incorrectly are rejected by the machine. They are hand-checked for the errors, and corrections are made accordingly.

Next, the cards were passed through the Calculating Punch Type 604 which reads the gross volume of the tree from the punched card, adjusts it for the proper cull defect class, and punches the net volume into the card. The cards were then ready for sorting by d.b.h. class, species, or other designation on the electronic sorter.

The final step was the compilation of the desired stand and stock table on a per acre basis. The cards pass through the Tabulator No. 402 which tabulates the information in summary final form.

The per acre stand and stock table for the plot on which the mark-sensing procedure was used showed 129.5 trees and 112.13 square feet of basal area; gross and net volumes were 13,039 and 12,019 board-feet, respectively. Time and cost data for this procedure are also summarized in Table 1.

KEY-PUNCHING

In the third method, an IBM portable manual key-punch was taken into the field, and the data were punched directly into the cards. The key-punch was mounted on a plywood base, with a shoulder strap for carrying. Elastic loops for cards were attached to the plywood base, along with a gross volume table for easy reference in obtaining gross volume data for each tree (Fig. 1).

As the cruiser called out the information for each tree, the "tally-man" punched the data into the cards, including the gross volume as read from the volume table. Each card was verified by a sight check to make sure the proper number of columns had been punched.

Next, the plot number was gang-punched into each card in the office. Then the cards were run through the Calculating Punch 602A, which read the d.b.h. of the tree as punched in the card, computed the basal area, and punched the basal area data into the card. The net volume was computed and punched into the cards by the Calculating Punch 604 which read the gross volume of each tree as punched in the

Fig. 1. The portable, manually-operated key-punch in field use.

TABLE 1—Comparative time and cost data for three forest inventory methods used in research

Operation performed	Inventory method used on a 2-acre plot					
	Regular cruise and manual office computation		Field mark-sensing and machine office computation		Field key-punching and machine office computation	
	Man-hours	Cost	Man-hours	Cost	Man-hours	Cost
Field measurement and recording of data*	6.67	$11.67	7.83	$13.70	6.17	$10.80
Computation and compilation of a stand and stock table*	12.25	21.44	...	...	...	...
Mark-sensing plot number, basal area, and gross volume data*	...	...	3.17	5.55	...	...
Gang-punching†	...	...	...	...	.25	.65
Reproducing	...	...	...	...	.75	1.95
Hand-checking	...	...	.25	.51	.25	.51
Sorting	...	...	.25	.55	.50	1.10
Computing basal area (Calculating Punch 602A)	...	...	...	...	.25	.86
Computing net volume (Calculating Punch 604)	...	...	.25	1.24	.25	1.24
Machine tabulating of a stand and stock table	...	...	.25	1.05	.25	1.05
Totals	18.92	$33.11	12.75	$24.55	7.92	$16.21

*The labor rate for these operations was $1.75 per hour, about that of the recruiting professional grade in the U. S. Forest Service at the time this study was made.

†The cost of gang-punching and all other tabulating machine operations are based on labor and machine rates as established by the tabulating department of Michigan State University. They have a 15-minute minimum charge for any operation or machine use.

card, adjusted it for the proper cull defect class, and punched the net volume data for the tree into the card.

The final step was the compilation of the stand and stock table on a per acre basis by the Tabulating Machine. The per acre values for the plot on which the field key-punching was used showed 142 trees and 107.14 square feet of basal area; gross and net volumes were 13,326 and 12,256 board-feet, respectively. Time and cost data for the field key-punching, computing, and tabulating procedure are shown in Table 1.

It should be noted that the mark-sensing of the plot number on the cards could have been replaced by gang-punching this data into the cards. Also, the basal area could have been computed and punched on the mark-sensing cards by the Calculating Punch 602A, as was done on the field key-punched cards. These two shortcuts would have reduced the mark-sensing total cost by about $3.15, bringing it down to about $21.40 for the plot.

DISCUSSION

If the minimum 15-minute charge by the Tabulating Department for any IBM procedure had not been applied, the cost savings from field key-punching and office tabulating would be even greater since some of the operations took less than 5 minutes. On larger scale operations, the gain in efficiency would be considerable.

The process of recording data in the field by the "tallyman" was most rapid by field key-punching, somewhat slower by regular tally listing, and slowest by mark-sensing the cards. The reasons for this point up some of the advantages and disadvantages of the three methods.

In the regular listing of data on a tally sheet, all information for one tree is placed on one horizontal line, and no searching for the proper location is necessary. In mark-sensing cards, however, the proper space on the card must be located exactly, both vertically and horizontally. Then, precise control of the pencil must be maintained so that the marks fill the proper spaces but do not overrun them. The reduced working space on a mark-sensing card compared to an ordinary field tally sheet increases the difficulty of proper placement.

It is possible that mark-sensing would show up better in this respect if only a few items of information were being recorded, such as a timber cruise for sale or purchase purposes.

The action of the portable key-punch is similar to that of a typewriter, so that less control is needed than in the use of the mark-sensing procedure. The card is placed in the machine and the carriage pushed back against the stop so that punching will begin in the desired column. Sight identification and manual depression of the proper key is all that is required for complete recording of data.

The field key-punched card is verified by sight-checking for a punch in the last required column; this insures that there are no double or missing punches. This is simpler than verifying a mark-sensed card, which requires a sight-check for marks in the proper number of columns, no omitted columns, and no double marks in the same column. The ordinary field tally listing is checked by making sure all columns on the tally sheet are filled.

Errors in both field key-punched and mark-sensed cards not detected by verification in the field will be located when the cards are machine processed. Any omission of columns or double entries in one column will stop the machine, and the errors can be corrected at that time.

Once the data are properly punched into the cards, there are very few chances of computational or tabulating errors in machine processing. In manual office computation and compilation of data into summary form, there are constant opportunities for errors, especially in transcribing data from one entry or form to another.

Mark-sensing and field key-punching techniques have some limitations. The portable key-punch weighs 15 pounds, and frequent moving by the operator from one location or plot to another may become tiring, especially in hilly terrain or through brushy understory conditions. In rainy weather, it would be hard to use either technique in the field without damage to the cards.

In cold weather, it is quite likely that field key-punching would be the easier method, since it would be simpler for the "tallyman" to find and press a key than to control his hand movements in accurately marking the card.

Capacity is an important advantage of field key-punching. In mark-sensing, 27 items can be recorded on one side of the card. If cards are printed and used for mark-sensing on both sides, a maximum of 54 spaces is available. Additional items require two cards for the same tree. New cards might have to be used for recording remeasurement data, and then the data transferred and punched by machine into the original card.

In field key-punching, 80 columns on the card are available for recording data. If perhaps half of the columns on the card are used in the original inventory, the same card could be field key-punched at one or more later inventories with remeasurement data for the same tree. Thus, data from several remeasurements can be combined on one card.

The amount of instruction needed by the "tallyman" to operate the portable key-punch should be no more than that for learning proper mark-sensing procedure. Simplified carrying equipment would reduce difficulty from that standpoint. Perhaps a simple tripod mounting would make field operation easier.

SUMMARY

Three inventory methods for recording and compiling forestry research data were applied to tree measurements from three 2-acre plots. In the first procedure, the data were listed on a field tally form, and final summary compilations were made by manual office compilation procedures. In the second procedure, the data were recorded in the

field on mark-sensing cards, and the final summary compilations were obtained by IBM tabulating machine procedures. In the third procedure, the data were key-punched into IBM cards in the field with a portable, manually-operated key-punch machine, and final compilations were made by IBM tabulating machine methods in the office.

Time and cost trials showed the field key-punching to be the fastest and cheapest; mark-sensing was next, and the ordinary field listing and manual office computing was the most costly. Field key-punching appears to be useful where the number of items to be entered on a card exceeds the mark-sensing maximum range of 54 columns on both sides of the card. Also, field key-punched cards can be used to record later remeasurements in the same manner; whereas new mark-sensing cards may be needed, and the remeasurement data would have to be transferred to the original cards.

Field key-punching is at least as accurate as mark-sensing, since the key-punch advances the card from one column to the next only when a punch is made, thus avoiding missed or double-punched columns. Both missed and double-marked columns are sources of error in field mark-sensing.

Key-punching IBM tabulating cards in the field offers possibilities in forestry research where much data are obtained at one location and subsequent measurements will be added later.

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MICHIGAN BROILER TEST NO. 3

SUMMER 1956[1]

By J. A. DAVIDSON, W. N. FISCHER and H. C. ZINDEL

DEPARTMENT OF POULTRY HUSBANDRY, AND W. K. KELLOGG FARM

PURPOSE OF TEST

THIS WAS A DESCRIPTIVE TEST of varieties, strains, and strain crosses under environment and management conditions at the W. K. Kellogg Farm, Hickory Corners, Michigan.

CONDITIONS OF TEST

The test was conducted on the ground floor of the two-story brooder house on the W. K. Kellogg Farm. Birds were entered on May 1, 1956. One hundred and four chicks (52 pullets and 52 cockerels) were required for an entry (Table 1). Each entry was placed in a pen of equal floor space (about 1 square foot per bird) which had been drawn by lot. Each chick was wing-banded for identification in order that a sample for the slaughtering data could be drawn.

If not debeaked when sent in, chicks were debeaked; they were then confined to a small area by a tight, solid corral for 2 days. Heat was supplied by heat lamps which were discontinued as soon as possible—between the fourth and fifth weeks. Ceiling lights were used to prevent bunching.

Chicks were fed from a small feeder placed on paper. The paper was removed the second day. Large feeders were substituted for smaller feeders as the chicks grew. All feeders were the same type for each pen. Small fountains were used at first until the chicks were large enough to use automatic waterers. Peanut shells and shavings were used for litter.

[1]Sponsored by the Michigan State Poultry Improvement Association.

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TABLE 1—Entrants and breeding groups

Entry No.	Breeder	Male	Female
47	Fairview Hatcheries Remington, Ind.	Fairview Vantress Dominant White	Fairview Barred Rocks
48	Fairview Hatcheries	Fairview Vantress Dominant White	Fairview Exp.
49	Gulliver's Hatchery Eaton Rapids, Mich.	Holtzapple Cross	Holtzapple
42	Holtzapple, W. R., Farm Elida, Ohio	Dominant White Cornish Cross	White Rock
43	Holtzapple, W. R., Farm	Holtzapple White Nick	White Rock
51	Klager Hatcheries Bridgewater, Mich.	Vantress Dominant White	Arbor Acres White Rock
52	Klager Hatcheries	Holtzapple White Rock	White Rock
44	Lambright Hatchery LaGrange, Ind.	White Meateor	Arbor Acres White Rock
45	Lambright Hatchery	Exp. Cross	No. 1
46	Lambright Hatchery	Exp. Cross	No. 2
41	Tice's Barred Rock Farm Barryton, Mich.	Vantress Dominant White	Barred Rock
53	Tice's B. R. Farm	Exp. Cross	
50	Townline Poultry Farm Zeeland, Mich.	White Rock	White Rock

DISEASE CONTROL

A coccidiostat (Ni-Carbazin) in the feed was used at recommended levels throughout the test. At 10 days, the chicks were vaccinated by the dust method for Newcastle disease. They were dusted again at 5 weeks for both Newcastle and bronchitis (this was delayed about a week by a slight misunderstanding on the part of one of the staff). Observation on the length of time required to recover from coughing and sneezing indicated that vaccination was harder on some groups.

WEIGHING AND SCORING

At 4 weeks and 7 weeks, each entry was group-weighed and the following information was obtained for the benefit of the breeder or hatchery: Average live weight, feed consumed, and number in each pen (Table 2). At 7 weeks, feathering was observed and individual birds checked for identity.

At 10 weeks of age, the birds were individually weighed, checked

TABLE 2—Feed conversion and mortality—10 weeks

Entry No.	Mortality	Pounds of chicken per 100 lb. feed	Feed per lb. of chicken	Number	
				Males	Females
	(percent)	(lb.)	(lb.)		
47	4.90	35.35	2.83	45	52
48	2.91	35.34	2.83	42	58
49	4.81	34.35	2.91	56	43
42	.97	37.39	2.67	52	50
43	4.95	34.99	2.86	48	48
51	5.56	37.11	2.70	48	54
52	4.81	33.08	3.02	47	52
44	1.92	36.73	2.72	51	51
45	.96	35.63	2.81	51	52
46	3.85	36.53	2.74	50	50
41	3.92	34.11	2.93	45	53
53	1.90	34.57	2.89	49	54
50	4.85	33.62	2.97	57	41
Average....	3.56	35.31	2.84	..	..

for sex, and a random sample of 10 of each sex was taken for slaughtering (Table 3).

The samples were mixed in pens where they remained overnight. They were loaded the next morning—20 in a crate—and transported

TABLE 3—Live weight and variability of each sex—10 weeks—entire group

Entry No.	Males		Females	
	Average weight	Variability*	Average weight	Variability*
	(lbs.)		(lbs.)	
47	3.84	10.84	3.03	8.83
48	3.93	8.1	3.03	8.83
49	3.7	7.16	2.86	8.45
42	4.03	9.03	3.12	7.23
43	3.73	10.11	2.93	7.72
51	4.01	8.3	3.27	6.79
52	3.41	9.29	2.76	7.14
44	3.97	7.5	3.05	7.9
45	3.7	7.16	2.86	7.72
46	3.74	11.46	3.02	7.47
41	3.89	6.79	2.97	6.67
53	3.63	7.86	2.78	8.0
50	3.4	13.15	2.75	9.46
Average.....	3.76	...	2.96	...

*Expressed as coefficient of variation. A low numerical value of the coefficient shows greater uniformity.

TABLE 4—Live and eviscerated weights of samples and carcass yields—10 weeks

Entry No.	Average weights				Carcass yields	
	Live		Drawn			
	Male	Female	Male	Female	Male	Female
	(lb.)	(lb.)	(lb.)	(lb.)	(Percent of live weight)	
47	3.82	2.96	2.79	2.3	73.04	77.70
48	3.83	2.95	2.78	2.19	72.58	74.24
49	3.42	2.98	2.48	2.22	72.73	64.50
42	3.94	3.07	2.89	2.25	73.35	73.29
43	3.56	2.86	2.65	2.16	74.44	75.52
51	3.91	2.98	2.92	2.4	74.68	80.54
52	3.53	2.78	2.67	2.09	75.64	75.18
44	4.04	3.11	3.05	2.39	75.50	76.85
45	3.75	2.88	2.72	2.13	72.53	73.96
46	3.79	2.96	2.76	2.14	72.82	72.30
41	3.69	3.1	2.76	2.25	74.80	72.58
53	3.68	2.75	2.66	1.96	72.28	71.27
50	3.44	2.69	2.49	1.95	72.38	72.49
Average...	3.72	2.93	2.74	2.19	73.61	74.67

*TABLE 5—Dressed score of samples—10 weeks**

Entry No.	Carcass grade†										
	Fleshing		Feathering		Fat		Conformation		Defects‡		Percent
	M	F	M	F	M	F	M	F	M	F	Grade "A"
47	1.8	2.0	1.0	1.1	1.6	1.3	1.5	1.5	1.4	1.2	70
48	1.8	2.0	1.1	1.1	1.2	1.4	1.5	1.6	1.4	1.2	75
49	2.0	2.2	1.1	1.1	1.4	1.5	1.6	1.4	1.5	1.2	50
42	1.7	1.9	1.0	1.2	1.4	1.3	1.3	1.6	1.2	1.2	95
43	2.2	2.2	1.1	1.0	1.5	1.5	1.5	1.3	1.8	1.3	65
51	1.3	1.8	1.1	1.0	1.6	1.3	1.4	1.4	1.8	1.4	90
52	2.0	2.3	1.2	1.0	1.5	1.5	1.4	1.4	1.6	1.3	70
44	1.3	1.8	1.0	1.0	1.4	1.3	1.1	1.2	1.4	1.3	100
45	1.4	2.0	1.1	1.1	1.4	1.4	1.3	1.4	1.4	1.3	90
46	1.3	1.8	1.0	1.1	1.5	1.7	1.3	1.2	1.4	1.2	90
41	1.6	1.8	1.2	1.0	1.5	1.4	1.4	1.3	1.5	1.4	100
53	1.7	2.1	1.0	1.2	1.5	1.4	1.4	1.4	1.7	1.3	85
50	2.0	2.4	1.0	1.1	1.5	1.5	1.4	1.4	1.3	1.3	60
Av....	1.68	2.0	1.05	1.06	1.43	1.4	1.36	1.36	1.45	1.25	..

*The authors express appreciation to Dr. L. E. Dawson, associate professor of poultry; and Hans Haugard district marketing agent, for scoring and grading of eviscerated carcasses.

†Dressed score: 1, 2, 3, 4, 5. Based on Federal Standards of Quality; average score shown.

‡Defects: Includes breast blisters, crooked and dented breast bones, crooked backs, etc.

to the Hamilton Farm Bureau, Hamilton, Michigan. There, live weights were taken as they hung on the dressing line. The eviscerated weights were recorded (Tables 4 and 5). The birds were scored following evisceration.

FEED

The chicks were fed a commercial broiler-starter until they were 7 weeks old. A broiler-finisher was used for the balance of the test.[2] The guaranteed analysis of the starter was crude protein, minimum 23.0 percent; crude fat, minimum 4.5 percent; and crude fiber, maximum 4.0 percent. The finisher was guaranteed to contain 20 percent protein, 4.5 percent fat, and not over 4.0 percent fiber.

LIMITATIONS

Results from such samples should not be interpreted competitively by entrants.

Relatively little reliance should be placed on information from only one test. Repeated testing will be required to reliably evaluate real performance of strains and strain crosses. It is hoped this attitude will be expressed by the entrants in using these data for other than their own information. A winner cannot be picked because of the problem of fairly evaluating the various characteristics which were observed.

[2]The feed for this third test was manufactured by the King Milling Company of Lowell, Michigan. This feed company had been selected by lot from the four feed mills operating in Michigan who indicated that they could supply a starter in crumble form.

THE COST OF REARING OFF-SEASON PULLETS VS. SPRING-HATCHED PULLETS AT THE UPPER PENINSULA EXPERIMENT STATION

A PROGRESS REPORT

By FLOYD W. HICKS[1]

THIS STUDY was made to provide information on the cost of rearing pullets to 20 weeks of age during three different periods of the year. It is a portion of a complete study at the Upper Peninsula Experiment Station comparing the economics of producing eggs during the season when egg prices are highest to year-round production.

In this resort area of the Upper Peninsula, consumer egg requirements are increased from June 15 to December 1 by the influx of tourists and sportsmen.

In producing eggs for the high-price season, it becomes necessary to hatch replacement chicks during what is known as the off-season. This is necessary so that these pullets can come into production, come through the "small egg" period, and be ready to lay large eggs in June or July. When the poultryman broods his replacement stock in late spring, those birds will produce few large eggs before November 1. One of the problems studied was: Is it possible to increase the net income of Upper Peninsula poultrymen by concentrating on maximum egg production from June to December? A second was: If producing eggs only during the high-price season will bring in as much income to the producer as brooding in the spring and producing eggs the year around, then, perhaps, net income will be higher for the time spent for operation of poultry enterprise. Naturally, some eggs will be needed the year around.

[1]District poultry agent, Cooperative Extension Service, Upper Peninsula Experiment Station, Chatham, Michigan.

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PROCEDURE

This study was conducted using a brooder house and three laying pens. The November hatch was started on November 15, the December hatch on December 14, and the April hatch on April 9. Each hatch was started in the same room in the brooder house and moved to other rooms later. At 10 weeks, the birds were culled and then placed in the pens of the laying houses. Similar laying pens were made by dividing the large pen with wire partitions.

Fuel costs were kept on each hatch; so were costs for feed, depreciation on buildings and equipment, litter, and medicine. Hours of labor time figures were not kept, because about the same amount of time was spent on each hatch. The time required to brood the chicks to 20 weeks of age was taken from studies in New York State. The poultryman at the Experiment Station is on salary; therefore, it was decided that other research results on time involved would be used in this study.

Chick Cost

The pullets used in this experiment were hatched from Chatham Station New Hampshires. The hatching eggs were custom hatched at the Manderfield Hatchery, Houghton County. New Hampshire pullet chicks were being sold by this hatchery at $34 per 100 chicks up to May 1955. Thus, the cost figure of $0.34 per chick was used for all three hatches. Chick cost was included in the cost of rearing.

Feed Cost

Chick grains were fed for the first 24 hours. After 24 hours, starting and growing mash was fed until the birds came into production. No attempt was made to bring the pullets into early production. Whole oats were fed free choice after the chicks were 8 weeks old.

The growing mash concentrate was mixed with farm-grown grains. This formula (based on materials which the local feed dealer could supply) was recommended by the Michigan State University poultry department. The formula contained: Alfalfa leaf meal (17 percent), 4.93 percent; meat and bone meal (50 percent), 2.48 percent; fish meal (60 percent), 2.48 percent; soybean oil meal (44 percent), 22.52 percent; curacao phosphate, 1.50 percent; calcium carbonate, 1.50 percent; iodized salt, .49 percent; Vitamin A and D Premix, .59 percent; manganese sulfate, .01 percent; and sulfaquinoxaline was added at one-quarter pound per 2 tons of concentrate.

To this concentrate, the following grains were added at the Experiment Station: Ground barley, 38 percent; ground yellow corn, 15

percent; ground oats, 10 percent; a vitamin concentrate containing riboflavin, pantothenic acid, niacin, choline and folic acid, 0.15 percent; and a vitamin B_{12} and antibiotic feeding supplement, 0.35 percent.

The current price reported by the Michigan Price Report[2] was used to establish the price of homegrown grains.

The pounds of feed fed each day were recorded and then totaled for each month. The average price was then used to calculate the feed cost per bird.

Grit and oyster shells, although low in cost in relation to other feedstuffs, are important. The grit was bought by the load at $6 per load of 2 yards. The oyster shells were secured at a cost of $2.20 per hundredweight.

For the November hatch, a total of 51 pounds of grit and oyster shells with a value of $0.01 per pullet was consumed; for the December and April hatches, the total cost per pullet was $0.03. The relative amounts used are included in the summary sheet as they occurred.

Labor Cost

The labor cost per pullet reared is based on the labor wage paid at the Upper Peninsula Experiment Station; it was $1.08 per hour through June 30, 1955, and $1.13 per hour thereafter.

Workers in New York State[3] found that 25 man-hours (MH) were required per 100 chicks to raise pullets to laying age. Indiana studies[4] show that 26.6 hours per 100 chicks are required (on semi-commercial poultry farms) to rear pullets to laying age. The figure of 25 man-hours was used as the basis for labor calculation in this experiment.

Using these figures, the total labor cost for the November hatch would be $0.37 per pullet. This labor cost is in close agreement with labor costs of $0.34 for heavy breeds on 167 New York farms in 1947.[5]

Buildings and Equipment Cost

The buildings used in this study were a multiple-room brooder house, a Michigan type laying house, a Michigan shed type laying house, and an old type of shed roof laying house. These buildings were not ideal for testing purposes, but they were the only ones available for use at the Experiment Station. Actually, the cost of buildings and

[2]Michigan Department of Agriculture (1956). Michigan Price Report. Mich. Dept. Agr., Bur. Agr. Ind., and O.S. Dept. Agr., Lansing.

[3]Ashe, A. J., James Holderness and C. Del. Mar Kearl (1950). Farm costs accounts. Cornell Univ. Agr. Ec. Pub. 757.

[4]Oberholtzer, J. W. (1943). An economics study of semi-commercial egg farms in north central Indiana. Purdue Univ. Agr. Ec. Bul. 486.

[5]Pickler, J. J. (1950). Cost of raising pullets on New York farms, 1947. Cornell Univ., Agr. Ec. Bul. 859.

equipment was low compared to other rearing costs. The actual valuation of these buildings was $250, $80, $90, and $35, respectively; the equipment used in this study included hand-attended brooders, waterers, feeders, etc., with a value of $150.

The November hatch was housed in the Michigan shed type; the December hatch in old type shed roof house; and the April hatch in the Michigan type. Charging 3 percent depreciation per chick on the brooding house and laying house and 10 percent on equipment (3 percent per hatch), the total housing and equipment cost per pullet would be $0.043 for the November hatch, $0.036 for the December hatch, and $0.043 for the April hatch. The complete year was charged to the hatches, even though the building was in use for only a portion of that time.

Fuel Cost

Wood was used as a source of heat, both for brooding and for supplemental heat in housing the pullets. The wood was cut from the Experiment Station woodlot into stove cords (16 by 4 by 8 inches). The price of this stove cord was figured from the price of a standard cord at Chatham ($13.00). A stove cord is about one-third of a standard cord (4 by 4 by 8 feet).

The brooder stoves were Shenandoah types, and the heating stoves for the laying houses were homemade, barrel types, surrounded by stone to prolong the heat and to make it more even.

Litter Cost

The litter material used for brooding and rearing was shavings obtained from a local planing mill. Experiment Station personnel and equipment were used to secure this material. The shavings were kept under a roof until used. The cost per load of 5 cubic yards came to $5.00 for labor and trucking costs.

More shavings were used in winter rearing than in spring rearing. The additional heat in the laying house provided by the use of barrel-type heaters was not enough to keep the moisture down, and the litter was replaced at intervals when stirring and further additions of shavings would not maintain it.

Medicinal and Disinfectant Costs

A sulfa drug was used to combat an outbreak of cecal coccidiosis. All laying pens and the brooder house were disinfected with a commercial disinfectant before housing the pullets and chicks. Whitewash

was used in the laying pens after they were disinfected. Cost of the sulfa drug, disinfectants, and carbolineum was $3.50 per hatch.

Mortality Costs

Costs of mortality are reduced by the hatchery practice of providing extra chicks with each chick order. Losses of chicks after the extra chicks are gone must be charged against the balance of the flock. Not only the chick cost but the feed, labor, etc., to date must be considered in estimating.

The high percentage of mortality during the first month following the April hatch was due to accidental smothering.

The highest mortality actually occurred at 10 weeks of age when the pullets were placed in the laying house. Those pullets with evidence of ocular leucosis were disposed of and recorded as a loss. The chicks were brooded fairly near old hens. Other workers have demonstrated that this practice does increase the incidence of leucosis over that when chicks are brooded some distance from the adult stock.

Mortality costs were not figured into the final cost of rearing the pullets, as the total rearing costs were charged up to the pullets housed.

Returns

The sale of cockerels, cull pullets and surplus pullets (not needed in later experiments) was credited to the rearing of the pullets. The surplus resulted from the limited capacity of the experimental pens.

The pullets were rigidly culled so that hatching eggs could be sold.

The surplus pullets were sold at the cumulative cost of rearing at the age sold; no profit was realized. The cockerels and cull pullets were sold for meat at the current market price quoted in the Daily Market Report.

It was reported in 1949[6] that 654 pounds of manure were produced per 100 chicks started. This manure was available at 1 cent per pound. The amount produced was 6.5 pounds per bird, and the value per bird was $0.065.

RESULTS AND DISCUSSION

Feed costs are presented in Table 1. Other costs, such as chicks, labor, fuel, buildings and equipment, litter and medicine, are presented in Table 2. All costs are summarized in Table 3.

The net cost per pullet for brooding and rearing for the three hatches of November, December, and April was $2.26, $1.91 and $1.99, re-

[6]Ashe, A. J. op. cit.

TABLE 1—Cost of feed in rearing pullets to 20 weeks of age

Item	November hatch	December hatch	April hatch
Number of chicks started	220	328	380
Number of pullets raised	160	205	182
Pounds of mash per pullet raised	27.6	24.2	34.4
Pounds of whole oats per pullet raised	4.2	6.9	1.1
Total feed used per pullet raised	31.8	31.0	35.5
Cost of mash per 100 lb	$3.76	$3.78	$3.85
Cost of grain per 100 lb	$2.22	$2.20	$1.94
Total feed cost	$180.90	$218.15	$244.81
Feed cost per pullet raised	$1.13	$1.06	$1.35

spectively. Note that only two-thirds as many chicks were started in November as in December and April; this increases capital investment charges per bird as well as others.

The fuel cost for brooding is a substantial factor. Less brooding equipment is necessary to brood the sexed pullets and, hence, a small investment is needed. To avoid undue crowding, however, the pullets were divided at 10 weeks to give extra room; just removing cockerels would accomplish this in straight-run hatches. At 10 weeks of age, the pullets were placed in the laying pens which had supplementary heat. The April hatch was placed on range at this age.

Pullets hatched in November or December were laying a high percentage of large eggs during the period of highest prices in the Upper

TABLE 2—Labor, litter, fuel and miscellaneous costs of rearing pullets to 20 weeks of age

Item	November hatch	December hatch	April hatch
Amount of fuel used (cords)	1¾	1⅛	4
Cost of fuel used	$63.88	$61.16	$17.33
Labor used—hours	55	82	95
Cost of labor	$59.40	$88.56	$104.50
Cost of chicks ($34 per 100)	$74.80	$111.52	$129.20
Amount of litter used	5 cu. yd.	5 cu. yd.	5 cu. yd.
Cost of litter	$5.00	$5.00	$5.00
Building and equipment costs	$15.20	$13.55	$14.90
Medicinal costs	$3.50	$3.50	$3.50
Oyster shell and grit cost	$3.12	$6.84	$4.97
Total costs	$224.90	$290.13	$279.40

TABLE 3—Summary of all costs and returns of rearing pullets to 20 weeks of age

Items of cost	November hatch	December hatch	April hatch
Feed cost	$180.90	$218.15	$244.81
Labor cost	59.40	88.56	104.50
Litter cost	5.00	5.00	5.00
Chick cost	74.80	111.52	129.20
Fuel cost	63.88	61.16	17.33
Miscellaneous cost	21.82	23.89	23.37
Total cost	$405.80	$508.28	$524.21
Meat return	$ 22.38	.....	$ 38.86
Surplus pullet return	7.50	$ 95.00	98.00
Manure value	14.39	21.45	24.85
Total return	$ 44.27	$116.45	$161.71
Net cost	$361.53	$391.83	$362.50
Total cost per pullet reared	$ 2.26	$ 1.91	$ 1.99

Peninsula, June 15 to December 1. The November and December pullets will normally begin producing eggs about April 15 and May 15, respectively. The April hatch pullets begin producing eggs about October 15.

Thus, even though the cost of producing the November and December reared pullets may be slightly higher than spring reared pullets, the income realized from the November and December pullets would result in greater gross income to the Upper Peninsula farmer. This would be due to available egg supplies during the Upper Peninsula's high egg price period, June 15 to December 1. This must be compared to the April reared pullets which would come into production in October, realizing only a month or so of high egg prices.

Reduction or depopulation of the laying stock about December 1 would make laying house space available for brooding space, especially during a period of low prices. It is possible that raising pullets for just the high price egg period might be more economical than year-around production with its cycle of high and low production.

A second phase of this experiment will provide more information of egg production costs at the Chatham Experimental Station.

MICHIGAN FARM BUSINESS REPORT FOR 1955

By JOHN C. DONETH

COOPERATIVE EXTENSION SERVICE AND THE AGRICULTURAL ECONOMICS DEPARTMENT

THE EARNINGS of Michigan farmers were further reduced in 1955. This marks the fourth consecutive year that farm earnings have declined since the peak earning year of 1951. The drop in earnings did not occur in all regions of the state. The Saginaw Valley cash crop and dairy area showed higher 1955 earnings, largely due to good crop yields. The eastern Michigan and Upper Peninsula dairy areas showed slightly better earnings due to the improved dairy situation.

This information was obtained from the farm records of 539 farmers distributed throughout the state. These farm accounts were kept as a part of the Cooperative Extension Program of the county agricultural agents in each county. The records were summarized under the supervision of farm management specialists in the agricultural economics department at Michigan State University.

FARM EARNINGS

The earnings, represented by labor income, are shown for the last 27 years, the length of time the project has been operating in Michigan (Table 1).

Labor income is what the farmer has left for his labor and management after all cash expenses, depreciation, family labor (other than the operator) and 5 percent interest on the investment have been deducted from gross income. The farm operator also receives the value of farm products used from the farm in the home, but this figure grows smaller each year. The farmer has his dwelling, but this is not considered in this report since no expenses against the home are included.

Another way of showing the financial condition of farmers is by breaking them down into earning groups. In such a breakdown, the percentage of farmers who went "in the red" in 1955 was the highest it has been since the depression years (Table 2). Thirty-four percent of

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TABLE 1—Farm earnings on farm accounting farms in Michigan, by years, 1929-1955

Year	Labor income	Year	Labor income
1929	$ 585	1942	$2,303
1930	−263	1943	1,990
1931	−676	1944	2,406
1932	−595	1945	2,483
1933	249	1946	3,374
1934	565	1947	3,486
1935	764	1948	2,735
1936	1,318	1949	1,815
1937	569	1950	2,688
1938	571	1951	3,782
1939	780	1952	2,926
1940	787	1953	2,447
1941	1,675	1954	1,755
		1955	993
27-year average (1929-55)			$1,537

TABLE 2—Percentage and distribution of labor incomes, 1929-55

Period	Total number of farms	Farms in each labor income group		
		0 or less	$1 to $1,000	$1,001 and over
		Percent	Percent	Percent
1929-33, 5-yr. av.	750	58	33	9
1934-38, 5-yr. av.	1,050	16	53	30
1939	1,346	14	54	32
1940	1,263	12	55	33
1941	1,041	5	27	68
1942	1,160	2	18	80
1943	1,097	8	24	68
1944	1,031	5	18	77
1945	939	6	17	77
1946	838	4	9	87
1947	830	5	11	84
1948	846	8	15	77
1949	912	9	16	75
1950	826	11	17	72
1951	685	7	9	84
1952	551	13	11	76
1953	501	20	14	66
1954	545	25	18	57
1955	539	34	17	49
27-year av. (1929-55)	887	20	22	58

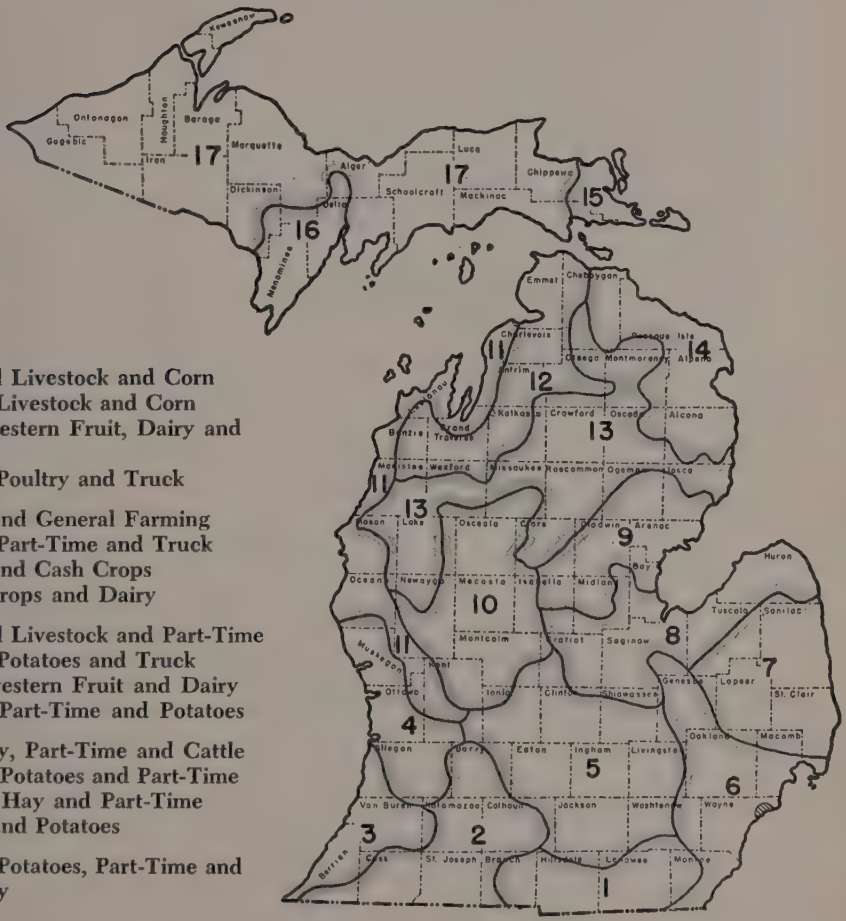
the 539 farmers had a labor income of zero or less, 17 percent had from $1 to $1,000, and the other half was above $1,000.

While these figures reveal in a general way what is taking place, they do not represent the average farmer. The account farms averaged 234 acres in size, compared to the average-sized Michigan farm of about one-half this acreage. All the farmers subscribed to good bookkeeping and had their businesses analyzed by the University. The earning figures between various years may not be entirely comparable, since the sample changes slightly from year to year.

The charge for family labor, the inventory values for feed and crops and also for nonbreeding livestock are changed each year in an attempt to keep the results in line with current conditions. Relatively fixed values are used for land, improvements and breeding stock. Real estate values listed in the account book by the farmers are about 60 percent of the present sale value estimated by them.

TABLE 3—Comparison of gross income, expenses, and labor income on accounting farms in Michigan, 1947 and 1950-1955

Item	1947	1950	1951	1952	1953	1954	1955
INCOME							
Crops	$2,663	$2,372	$2,646	$2,872	$3,143	$3,643	$2,521
Dairy products	3,456	3,439	4,574	5,410	5,676	4,994	5,476
Cattle	1,082	1,719	2,165	1,666	1,055	1,438	1,514
Hogs	949	865	1,034	952	1,038	1,049	620
Poultry and eggs	805	810	992	995	1,131	946	1,125
Sheep	126	151	187	95	113	131	100
Other	351	447	497	526	289	698	737
	$9,432	$9,803	$12,095	$12,516	$12,445	$12,899	$12,093
EXPENSES							
Feed	$1,231	$1,192	$1,502	$1,726	$1,634	$1,832	$1,655
Machinery	1,162	1,658	1,939	2,253	2,445	2,707	2,889
Hired labor	634	684	739	888	929	1,011	886
Crop expense	770	774	1,111	1,303	1,395	1,523	1,490
Family labor	468	449	487	467	485	619	639
Improvements	349	454	526	617	667	764	768
Taxes	128	168	185	223	241	273	317
Other	216	482	427	502	530	562	578
	$4,958	$5,861	$6,916	$7,979	$8,326	$9,291	$9,222
Net farm income	$4,474	$3,942	$5,179	$4,537	$4,119	$3,608	$2,871
Interest on investment at 5%	988	1,254	1,397	1,611	1,672	1,853	1,878
LABOR INCOME	$3,485	$2,688	$3,782	$2,926	$2,447	$1,755	$ 993



General Livestock and Corn
Dairy, Livestock and Corn
Southwestern Fruit, Dairy and Truck
Dairy, Poultry and Truck

Dairy and General Farming
Dairy, Part-Time and Truck
Dairy and Cash Crops
Cash Crops and Dairy

General Livestock and Part-Time
Dairy, Potatoes and Truck
Northwestern Fruit and Dairy
Dairy, Part-Time and Potatoes

Forestry, Part-Time and Cattle
Cattle, Potatoes and Part-Time
Cattle, Hay and Part-Time
Dairy and Potatoes

Dairy, Potatoes, Part-Time and Forestry

Fig. 1. Type of farming areas in Michigan.

EXPENSES STAY HIGH

One item that has put a squeeze on farm earnings is high expenses. Agricultural production has been at record levels; this has forced prices for almost all agricultural products down. At the same time, the costs of things that farmers buy have been creeping upward for years. Total expenses on the farms in this report did not change much between 1954 and 1955 (Table 3). Gross income dropped off about $800 per farm; this accounted for just about all of the fall in labor income.

Price declines occurred for some crops and in certain kinds of livestock; as a result farmers, took in less cash. They met this partly by

*TABLE 4—Cash summary for all farms and for various areas**

	All farms	1	2	3 and 11	4	5	6 and 7	8	9-12-14	10	15-16-17
CASH INCOME											
Crop sales	$ 2,761	$ 3,025	$ 2,018	$15,804	$ 1,063	$ 2,773	$ 1,989	$ 4,432	$ 907	$1,352	$ 733
Dairy products	5,476	4,570	6,331	1,703	3,914	6,501	7,364	5,892	4,649	5,203	4,632
Dairy cattle	1,062	800	1,162	396	1,019	1,196	1,430	1,061	1,120	1,148	733
Beef	1,102	4,018	585	57	404	1,312	840	929	706	346	...
Eggs	766	967	612	672	3,775	647	561	498	346	479	627
Poultry meat	488	137	874	96	656	1,050	148	337	326	105	106
Hogs	758	1,479	1,618	77	228	1,212	443	510	290	187	18
Sheep and wool	151	184	228	...	16	295	171	66	96	...	33
Custom work	197	298	370	166	41	235	117	231	120	192	58
Labor off farm	275	204	119	408	191	203	226	300	376	479	439
Machinery cash sales	123	235	81	53	45	172	118	56	75	150	88
Other sources	272	247	165	373	262	326	324	237	193	318	273
Total	$13,431	$16,164	$14,163	$19,805	$11,614	$15,922	$13,731	$14,549	$9,204	$9,959	$7,740
CASH EXPENSES											
Purchased feed	$ 1,655	$ 2,087	$ 2,175	$ 942	$ 3,352	$ 1,872	$ 1,336	$ 1,428	$1,151	$ 937	$1,183
New machinery bought	1,583	1,523	1,387	2,705	1,051	1,898	1,981	1,896	1,008	1,546	890
Other machinery expense	1,596	1,593	1,679	3,677	1,092	1,798	1,663	1,501	1,176	1,411	952
New improvements	609	750	415	340	522	771	1,137	886	242	198	405
Other improvement expense	314	387	281	370	274	456	327	254	179	226	170
Livestock bought	982	2,380	1,165	147	814	1,435	570	831	438	390	159
Other livestock expense	265	222	351	104	150	352	357	295	207	201	142
Hired labor	886	617	862	5,289	496	845	694	992	270	659	535
Crop expense	1,192	1,301	1,313	1,212	803	1,568	1,496	1,356	743	956	467
Custom hire	204	255	240	163	179	212	229	265	129	229	123
Taxes	317	388	360	317	276	400	416	341	178	230	119
Other expense	312	285	343	403	255	360	376	379	239	235	212
Total	$ 9,915	$11,788	$10,571	$15,669	$ 9,264	$11,967	$10,582	$10,424	$5,960	$7,218	$ 5,357

TABLE 4—Concluded

	All farms	1	2	3 and 11	4	5	6 and 7	8	9-12-14	10	15-16-17
INVENTORY CHANGE											
Farm improvement	$ 149	$ 324	$ −32	$ −118	$ 30	$ 127	$ 518	$ 389	$ −31	$ −65	$ 46
Orchard	...	...	...	289	...	...	...	...	...	...	...
Machinery	72	−63	−90	701	−134	67	261	303	−90	189	−38
Feed and crop	−240	−466	−646	−852	−420	−334	7	431	−218	8	50
Hogs	−78	−178	−132	−10	18	−137	−36	−64	−30	−20	9
Sheep	−27	−39	−56	...	...	−62	−37	27	−4	...	−2
Poultry	−13	9	−62	+59	35	−14	19	−62	−20	−44	−8
Dairy cattle	76	178	215	−34	−7	6	385	−2	14	−38	3
Beef cattle	55	2	58	−37	172	170	−13	134	−27	−70	−2
Other	...	...	3	+37	−6	−1	4	...	...	−2	1
Net inventory change	−6	−233	−742	+35	−312	−178	1,108	1,156	−406	−42	59
SUMMARY											
Net cash income	$ 3,516	$ 4,376	$ 3,592	$ 4,136	$ 2,350	$ 3,955	$ 3,149	$ 4,125	$3,244	$2,741	$ 2,383
Inventory increase	−6	−233	−742	+35	−312	−178	1,108	1,156	−406	−42	59
Net income	3,510	4,143	2,850	4,171	2,038	3,777	4,257	5,281	2,838	2,699	2,442
Family labor	639	592	510	695	692	651	883	559	601	660	588
Net farm income	2,871	3,551	2,340	3,476	1,346	3,126	3,374	4,722	2,237	2,039	1,854
Interest on investment	1,878	2,131	1,953	1,948	1,472	2,397	2,176	1,970	1,351	1,387	1,013
Labor income	993	1,420	387	1,528	−126	729	1,198	2,752	886	652	841

*For key to areas, See Fig. 1.

cutting expenses, especially for new improvements and machinery. However, the drop in prices caused considerable reduction in inventory values, and these the farmers could do nothing about.

The financial summary including cash income, cash expenses, inventory charge, and earning summary are shown in Table 4 for all account farms and also for each of the various areas in the state (Fig. 1).

Physical changes have also occurred on the farms (Table 5). The size of total acres per farm has increased 41 acres; tillable acres have increased 33 acres. The amount of livestock has increased 40 percent, while the labor force has stayed the same. Labor efficiency, as measured by work units per man, has gone up 35 percent.

TABLE 5—Comparison of size of farm, amount of livestock, and amount of work, 1947 and 1950-1955

Item	1947	1950	1951	1952	1953	1954	1955
Number of farms.....	830	826	685	551	501	545	539
Total acres.....	193	201	210	223	224	230	234
Tillable acres.....	134	318	146	156	160	166	167
Animal units.....	27.1	31.7	31.6	36.3	36.4	37.5	38.0
Man-work units*.....	473	493	529	562	593	597	622
Number of men*.....	1.7	1.6	1.7	1.7	1.6	1.7	1.7
Work units per man*...	286	303	319	306	360	358	387

*Fruit farms excluded.

TYPE-OF-FARMING AREA INFORMATION

The figures and information presented concern an average of all account farms throughout the state. In addition to state average figures, Tables 6, 7, 8 and 9 give information for 10 type-of-farming districts in the state. Some areas have been combined, so that results are represented by districts rather than by each individual type of farming area.

The data presented include a financial summary; the kinds of crops grown, their yields and the percentage of tillable land in each crop; the kinds, amounts, and returns from livestock; and the various expenses and their relationships to each other.

TABLE 6—Financial summary of 539 Michigan account farms by type-of-farming area, 1955

Item	All farms	Type-of-farming area									
		1	2	3 and 11	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	539	59	51	24	27	131	52	42	68	36	49
Total acres	234	214	229	155	172	263	250	167	277	252	222
Percent of farm acres tillable	71	80	78	73	74	76	80	74	57	64	51
Tillable acres	167	173	179	113	128	201	199	134	157	162	114
Real estate (less house)*	$20,083	$22,330	$20,281	$23,224	$14,898	$25,978	$24,218	$22,413	$13,513	$14,034	$ 9,905
Real estate (present sale value)	34,762	44,182	36,330	35,220	27,026	45,215	44,744	39,258	19,537	22,544	13,537
Machinery and equipment*	7,937	7,935	7,976	9,867	7,344	9,346	8,683	8,012	6,384	6,906	5,568
Livestock*	5,429	6,288	6,400	1,735	3,981	6,888	6,139	4,687	4,995	4,502	3,257
Feed and crops*	4,145	6,127	4,367	4,139	3,217	5,738	4,422	4,289	2,123	2,297	1,528
Capital investments*	$37,594	$42,680	$39,024	$38,965	$29,440	$47,950	$43,462	$39,401	$27,015	$27,739	$20,258
Livestock income	$ 8,835	$ 9,748	$10,272	$ 2,872	$ 9,419	$10,737	$10,716	$ 8,492	$ 7,028	$ 6,905	$ 5,993
Crop income	2,521	2,558	1,372	14,950	643	2,440	1,996	4,864	688	1,360	783
Other income	737	725	642	1,238	481	747	647	760	689	979	669
Gross income	$12,093	$13,031	$12,286	$19,060	$10,543	$13,924	$13,359	$14,116	$ 8,405	$ 9,244	$ 7,445
Total expense†	9,222	9,480	9,946	15,584	9,197	10,798	9,985	9,394	6,168	7,205	5,591
Net farm income	$ 2,871	$ 3,551	$ 2,340	$ 3,476	$ 1,346	$ 3,126	$ 3,374	$ 4,722	$ 2,237	$ 2,039	$ 1,854
Less interest at 5 percent	1,878	2,131	1,953	1,948	1,472	2,397	2,176	1,970	1,351	1,387	1,013
Labor income 1955	$ 993	$ 1,420	$ 387	$ 1,528	$ −126	$ 729	$ 1,198	$ 2,752	$ 886	$ 652	$ 841
Labor income 1954	1,755	3,079	1,172	3,080	917	2,451	786	2,238	916	918	588
Labor income 1953	2,447	3,283	2,142	5,402	1,914	2,999	1,542	3,403	1,296	1,537	916
Labor income 1952	2,926	2,984	2,916	3,860	2,930	3,589	3,103	3,742	1,826	2,485	1,797
Labor income 1951	3,782	4,533	4,845	2,765	3,752	5,173	3,633	4,726	2,309	3,233	1,888
Labor income 1950	2,688	3,389	3,309	3,239	2,885	3,687	2,041	4,057	1,148	2,300	1,364
Labor income 1949	1,815	20,79	2,160	1,065	1,927	2,647	2,538	2,955	875	1,564	610
Labor income 1948	2,735	3,954	2,903	1,962	2,930	3,014	3,151	3,777	1,938	2,517	1,782
Labor income 1947	3,486	4,596	4,300	1,930	3,753	4,710	3,328	4,501	1,926	2,391	2,134
Labor income 1946	3,374	4,337	3,169	6,007	3,011	3,312	3,205	4,413	2,253	2,485	2,460
Labor income, 10-year average 1946–1955	$ 2,600	$ 3,365	$ 2,730	$ 3,084	$ 2,389	$ 3,231	$ 2,453	$ 3,656	$ 1,537	$ 2,008	$ 1,438

*Investment figures tend to represent longtime account book values and not current valuations.
†Includes family labor but not operator's labor or interest on investment.

TABLE 7—Kinds of crops, percentage of tillable land in different crops, and yields by type-of-farming area in Michigan, 1955

Item	All farms	Type-of-farming area									
		1	2	3 and 11	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	539	59	51	24	27	131	52	42	68	36	49
Number of tillable acres	167	172	179	113	128	201	199	134	157	162	114
Percent in sod crops	...	33	48	19	40	42	48	23	63	55	67
Percent in legumes	32	28	40	15	27	32	26	30	34	10	38
Percent tillable acres in:											
Tillable pasture	17	10	21	8	18	16	20	12	24	20	21
Alfalfa hay	13	11	18	4	12	14	14	15	14	15	8
Other hay	12	10	7	8	9	9	11	7	20	14	37
Grass silage	2	2	3	...	...	3	2	...	4	6	1
Corn (includes corn silage)	21	33	23	5	26	25	20	21	12	15	5
Wheat	8	10	9	3	11	10	8	9	4	6	1
Oats (oat mixture)	15	16	13	5	16	15	15	12	14	12	22
Barley	1	1	2	...	2	1	1	2	...	...	...
Beans	2	1	...	...	...	1	3	12	...	...	...
Sugar beets	...	...	...	...	...	...	...	6	...	...	...
Potatoes	...	...	...	...	...	...	...	...	...	1	2
Fruit and truck	2	...	...	50	...	...	...	...	...	...	...
Other	4	4	2	4	2	3	3	3	4	6	1
Idle	3	2	2	13	4	3	3	1	4	5	2
Crop yield per acre:											
Alfalfa hay, ton	2.5	2.8	2.6	2.4	2.8	2.7	2.3	2.7	1.8	2.5	2.3
Other hay, ton	1.9	2.1	1.9	1.9	1.9	2.0	1.5	2.9	1.7	1.8	2.0
Grass silage, ton	4.4	...	5.1	...	...	4.8	4.6	...	3.8	4.2	2.6
Corn shelled, bu	55	67	44	48	42	56	55	63	46	33	...
Wheat, bu	33	33	30	38	32	34	33	44	26	29	24
Oats, bu	50	55	46	58	51	54	53	68	33	46	40
Barley	36	34	33	...	30	40	37	46	...	...	..
Beans, bu	19	27	...	...	...	12	16	23	...	...	...
Sugar beets, ton	...	...	...	...	...	...	...	16.8	...	...	..
Potatoes, bu	...	...	...	...	...	...	...	...	...	242	239
Crop yield index	100	113	93	...	94	105	96	123	79	87	94
Crop value per tillable acre	$ 43	$ 53	$ 38	$ *	$ 39	$ 44	$ 45	$ 64	$ 31	$ 37	$ 36
Crop sales and ASC payments	2,761	3,025	2,018	15,804	1,063	2,773	1,989	4,432	907	1,352	733
Crop income total	2,521	2,558	1,372	14,950	643	2,440	1,996	4,864	688	1,360	783
Feed bought	1,655	2,087	2,175	942	3,353	1,872	1,336	1,427	1,151	937	1,183
Fertilized per til. acre	4.60	5.55	5.28	3.29	4.66	5.48	5.00	7.35	3.05	3.75	2.64

*Not comparable.

TABLE 8—Livestock: kinds, amounts, and returns from livestock by type-of-farming area in Michigan, 1955

Item	All farms	Type-of-farming area									
		1	2	3 and 11	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	539	59	51	24	27	131	52	42	68	36	49
Livestock income total	$ 8,835	$ 9,748	$10,272	$ 2,872	$ 9,419	$10,737	$10,716	$ 8,492	$ 7,028	$ 6,904	$ 5,993
Livestock income per T. A*	53	57	57	51	74	53	54	63	45	43	53
Productive animal units	38.0	41.0	45.6	11.4	29.4	46.9	42.7	31.0	35.4	33.3	28.3
Tillable acres per P.A.U†	4.4	4.2	3.9	4.9	4.4	4.3	4.7	4.3	4.4	4.9	4.0
Cattle:											
Percent farms reporting	90	85	94	58	96	89	90	90	94	97	100
Cows per farm reporting	19.4	16.3	21.1	10.1	14.4	22.1	23.7	18.0	18.0	19.1	18.8
Dairy product sales per cow	$ 312	$ 330	$ 319	$ 280	$ 282	$ 331	$ 344	$ 362	$ 275	$ 280	$ 246
Dairy sales per farm reporting	6,049	5,393	6,726	2,919	4,064	7,342	8,138	6,513	4,939	5,352	4,632
Income per farm reporting	4,533	6,570	4,016	948	4,029	3,906	1,496	3,380	3,773	2,886	629
Hogs:											
Percent farms reporting	38	56	57	...	37	49	21	29	43	22	8
Sows per farm reporting	4.8	4.6	7.9	...	1.5	5.2	3.7	6.0	2.1	1.9	2.3
Litters farrowed per farm	8.3	10.8	12.3	...	3.6	9.4	9.5	8.3	3.3	3.1	3.0
Pigs weaned per litter	6.9	6.6	7.2	...	7.6	6.6	7.8	6.1	7.2	6.4	6.0
Hog income per litter	$ 189	$ 182	$ 200	$ ...	$ 165	$ 196	$ 192	$ 152	$ 172	$ 197	$ 91
Income per farm reporting	1,637	2,085	2,484	...	592	1,974	1,817	1,394	580	617	273
Sheep:											
Percent farms reporting	12	17	12	...	7	18	13	10	12	...	6
Ewes per farm reporting	43	15	56	...	15	53	50	36	48	...	29
Lambs raised per 100 ewes	95	83	95	...	77	96	89	101	97	...	121
Sheep income per ewe	$ 19	$ 15	$ 26	$ ...	$ 14	$ 18	$ 18	$ 27	$ 16	$ ...	$ 17
Income per farm reporting	858	418	1,445	...	62	991	951	974	750	...	491
Poultry:											
Percent farms reporting	62	68	59	42	85	66	60	52	56	64	61
Hens per farm reporting	209	263	182	313	716	175	153	169	83	134	143
Egg sales per hen	$ 5.82	$ 5.44	$ 5.72	$ 5.15	$ 6.19	$ 5.56	$ 6.09	$ 5.63	$ 5.53	$ 5.56	$ 7.16
Egg sales per farm reporting	1,216	1,427	1,040	1,612	4,432	974	930	952	457	747	1,025
Meat income per farm reporting	$ 580	$ 155	$ 956	$ 247	$ 457	$1,275	$ 212	$ 369	$ 451	$ 19	$ 85

*T.A. = Tillable acre.
†P.A.U. = Productive animal unit.

TABLE 9—Expenses and efficiency factors, labor, machinery, improvements and other costs by type-of-farming area in Michigan, 1955

Item	All farms	Type-of-farming area									
		1	2	3 and 11	4	5	6 and 7	8	9-12-14	10	15-16-17
Number of farms	539	59	51	24	27	131	52	42	68	36	49
Gross income per T. A.	$ 72.54	$ 75.74	$ 68.73	$168.41	$ 82.37	$ 69.16	$ 67.19	$105.40	$ 53.59	$ 56.99	$ 65.49
Total expense per T.A.*	67.61	67.98	67.85	156.08	87.38	64.47	61.24	85.73	50.46	56.64	63.90
Total expenses*	11,272	11,696	12,129	17,664	11,186	12,979	12,177	11,482	7,913	9,187	7,264
Man labor:											
Number of men	1.7	1.6	1.5	3.3	1.5	1.7	1.8	1.5	1.5	1.6	1.5
Income per man	$ 7,194	$ 8,348	$ 7,659	$ 5,820	$ 7,134	$ 8,325	$ 7,494	$ 9,263	$ 5,525	$ 5,631	$ 4,845
Days of work per man†	387	411	421	...	358	432	396	375	350	342	313
Hired	$ 886	$ 617	$ 862	$ 5,289	$ 496	$ 845	$ 694	$ 991	$ 270	$ 659	$ 535
Family	639	592	510	695	692	651	883	559	601	660	588
Operator	2,050	2,216	2,183	2,081	1,989	2,181	2,192	2,088	1,745	1,982	1,673
Expense per T.A.	21.44	19.90	19.89	71.26	24.82	18.26	18.96	27.17	16.67	20.35	24.59
Power and machinery:											
Investments	$ 7,937	$ 7,935	$ 7,976	$ 9,867	$ 7,344	$ 9,346	$ 8,683	$ 8,012	$ 6,384	$ 6,906	$ 5,568
Income per $1,000 investment	1,440	1,642	1,540	1,932	1,436	1,490	1,539	1,762	1,317	1,339	1,337
Annual expense	2,889	2,942	3,077	3,513	2,232	3,458	3,266	3,037	2,200	2,618	1,787
Expense per T.A.	17.33	17.10	17.21	31.04	17.44	17.18	16.43	22.68	14.03	16.14	15.77
Improvements:											
Investment (less house)	$ 9,870	$10,817	$10,145	$ 7,802	$ 8,176	$13,123	$12,727	$10,992	$ 6,467	$ 6,284	$ 5,053
Investment per P.A.U.	260	264	222	...	278	281	298	355	183	189	179
Annual expense	$ 768	$ 790	$ 715	$ 828	$ 760	$ 1,083	$ 931	$ 744	$ 450	$ 480	$ 434
Expense per T.A.	4.61	4.59	4.00	7.32	5.94	5.38	4.68	5.54	2.87	2.96	3.77
Feed bought	$ 1,655	$ 2,087	$ 2,175	$ 942	$ 3,353	$ 1,872	$ 1,336	$ 1,427	$ 1,151	$ 937	$ 1,183
Crop expense	1,286	1,301	1,313	3,327	803	1,567	1,496	1,356	744	957	468
Custom hire	204	255	240	163	179	212	229	265	129	229	123
Taxes (real estate)	317	388	360	317	276	400	416	341	178	230	119
Other expenses	578	508	694	509	406	710	734	674	445	435	354
Feed bought per T.A.	$ 9.93	$ 12.13	$ 12.17	$ 8.32	$ 26.19	$ 9.30	$ 6.72	$ 10.66	$ 7.34	$ 5.77	$ 10.41
Crop expenses per T.A. (less custom)	7.72	7.56	7.35	29.39	6.27	7.79	7.53	10.12	4.74	5.90	4.12
Custom work per T.A.	1.22	1.48	1.34	1.44	1.40	1.05	1.15	1.98	.83	1.41	1.08
Real estate tax per T.A.	1.90	2.25	2.01	2.80	2.15	1.99	2.09	2.55	1.14	1.42	1.04
Other expenses per T.A.	$ 3.46	$ 2.97	$ 3.88	$ 4.51	$ 3.17	$ 3.52	$ 3.68	$ 5.03	$ 2.84	$ 2.69	$ 3.12

*Includes operator's and family labor, but not interest on investment.
†Fruit farms excluded.

A STUDY OF ALDER ON FOREST LANDS IN MICHIGAN

By MAURICE W. DAY

DUNBAR FOREST EXPERIMENT STATION

A CONSIDERABLE AREA of potential Michigan timberland is occupied by stands of lowland brush; one of the principal species of this type is alder. The desire to convert these lands to valuable timber species has led to a consideration of the ecology of alder.

There appears to be very little published material on the ecology, silviculture, and life history of alder in America. There are quite a number of reports dealing with alder in Europe; however, it appears that this material is dealing with a different species growing under different conditions, since Fernald[1] reports that the two species have been confused for many years.

Some attention should be given the taxonomy of the species being considered. *Alnus incana* is the scientific name usually associated with speckled alder (also known as tag alder); however, this name has also been applied to the common alder of Europe. According to Fernald, the classification of this genus has been radically changed. *Alnus incana* is now restricted to Europe, while speckled alder is named *Alnus rugosa* (DuRoi) Spreng. However, the species is described as limited to southern Canada and the northeastern United States, while the alder occurring in the Lake States is described as *Alnus rugosa* (DuRoi) Spreng var. Americana (Reg.) Fern.

The variety differs only in that the lower surface of the leaves are glaucous, while in the typical species they are not. This characteristic is quite variable, and an examination of the leaves of alder growing in Michigan leads one to wonder if the establishment of a variety is justified.

[1]Fernald, M. S. (1950). *Gray's Manual of Botany.* 8th Ed. American Book Company, New York.

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PROCEDURE

This study of alder was conducted at the Dunbar Forest Experiment Station in the eastern upper peninsula of Michigan. The alder stands here are quite typical of much of northern Michigan and are found on a variety of sites. Most of the alder areas are characterized by poor surface drainage and a relatively high ground water level during part of the growing season. All of the areas have been subjected to some degree of cutting, and in some cases fire has been part of the recent stand history.

Most of the alder stands studies occurred on Munuscong fine sandy loam. This soil has a heavy clay layer quite close to the surface and is a member of the Low-Humic Gley group. Alder is also commonly found on organic soils and imperfectly drained Podzols or Gray Wooded soils.

A group of five quarter-acre permanent sample plots right next to each other were established in 1933 under the direction of P. W. Robbins. An adjoining plot of 1 acre was established in 1937. A number of similar temporary plots have been established in recent years in connection with work on silvicides.

On the plots laid out in 1933, complete records have been kept, including cover present before treatment as well as a record of the reproduction since. Quadrats and transects were laid out to record the appearance and growth of reproduction.

As a control and as a seed source for the other plots, one plot was left untouched since it contained mature balsam fir, white spruce, tamarack, and balsam poplar. The treated plots were grouped around the control plot. On three of the plots, the alder was clear-cut with varying degrees of slash disposal. On the fourth plot, every other alder clump was girdled. Each of the four treated plots has a scattered stand of tree species left standing; this stand (largely balsam poplar) varies from 20 trees per acre to 84 trees per acre, 4 inches d.b.h. and up.

TABLE 1—Reproduction appearing on treated areas

Treatment of alder	New stems appearing during first seven areas				
	Balsam fir	Aspen	Balsam poplar	White spruce	Others
Clear-cut.....	506	300	528	0	0
Girdled.....	375	0	0	0	0
Control.....	2,680	40	67	62	0

TABLE 2—Reproduction on treated areas

Treatment of alder	End of 7-year period				Persisting to end of 10-year period			
	Balsam fir	Aspen	Balsam poplar	White spruce	Balsam fir	Aspen	Balsam poplar	White spruce
Clear-cut...	69	200	283	0	32	128	288	0
Girdled.....	125	0	0	0	0	0	0	0
Control.....	250	22	40	0	250	0	4	0

Detailed reproduction counts were made for 7 years; at the end of 10 and 20 year periods, a complete study of the project was made.

Data are summarized in Tables 1 and 2.

At the end of the 10-year period, the best of the clear-cut plots had a stocking of 572 stems per acre; averages were 2.1 inches d.b.h. for the balsam poplar and 1.5 inches for the aspen. To increase the stocking this area was clear-cut again, cutting alder as well as aspen and balsam poplar.

DISCUSSION

At the end of a 20-year period, the plots were re-examined and the following conclusions made:

1. Clear-cutting of the alder resulted in the appearance of groups of aspen and balsam poplar suckers, but there were not enough to fully restock the area. The areas were restocked with a vigorous sprout growth of alder.

2. Girdling of half of the alder stand resulted in no change in stand composition. No reproduction of other species appeared as a result.

3. While large numbers of balsam fir seedlings appeared after the treatment, very few survived more than 5 years. After 20 years, the additional stocking of this species on any of the plots was insignificant.

4. The only changes in density in the alder stand resulted from the growth of the aspen and balsam poplar present before the treatment. In the 20-year period, these trees grew from the 3- to 6-inch d.b.h. class into the 9- to 12-inch d.b.h. class.

5. All openings in the alder stand were occupied by a heavy stand of grasses which seemed to prevent the appearance of any young growth of desirable species.

6. The 1943 cutting resulted in a dense stand of vigorous alder sprouts which reached a maximum height of 6 feet the second year after cutting. The stocking of aspen and balsam poplar was about equal to that before cutting, and they would have overtopped the alder if they had not been defoliated for several years by the forest tent caterpillar.

The adjoining area cut in 1937 gave contrasting results. This area had a pure even-aged stand of balsam poplar containing 12,500 board-feet per acre in 112 stems per acre, 9 inches d.b.h. and up. The alder stand which made up the understory, together with other shrub species (mainly willow and dogwood), was considerably lighter and less vigorous. This area was clear-cut, followed by a cutting of the alder that had not been destroyed in the logging.

Ten years after logging, this area had a stand of balsam poplar and aspen amounting to 3,084 stems per acre and averaging 2.1 inches d.b.h. The success of this cutting probably lies in the size, number, and distribution of the tree species at the time of cutting as well as the greater age and lower vigor of the alder stand. No noticeable stocking of conifers has taken place here, despite the presence of a few seed trees.

REVIEW OF OTHER STUDIES

An independent study by Brickman[2] on the ecology of alder was made in the same general area in 1950. He found alder, during its seed germination period, to be a primary invader on denuded sites having a saturated soil surface. On sandy sites, the tendency appeared to favor the mixed swamp conifer: denuded swamp hardwood stands which revert to an alder-swamp hardwood type and then to swamp hardwoods. On organic soils, the tendency is for alder to be slowly replaced by the conifers.

When alder occurs with aspen and balsam poplar, the tendency is for the alder to displace the latter species. Brickman also found that fire, as well as most logging, favored alder over competing species (particularly the conifers) and that the displacement of alder usually requires a long period.

Brown[3] studied the life history of this species in Minnesota and found that, while it regenerates by seeds, sprouts, layers, underground

[2]Brickman, T. L. (1950). Ecology of speckled alder at the Dunbar Forest Experiment Station. Thesis for degree of M. S., Mich. State Univ., East Lansing. (Unpublished)

[3]Brown, Bruce A. (1953). A preliminary investigation of the life history of Speckled Alder Alnus rugosa (DuRoi) Spring. var. Americana (Reg.) Fern in northeastern Minnesota. Univ. Minn. School of Forestry Res. Rep. (Unpublished)

stems and suckers; seed is the primary method of establishment on a new area, and sprouting is the principal means of perpetuation. Growth of seedlings was relatively slow (40 inches height in 6 years) and was not a competing factor with tree reproduction given the same start. On the other hand, Brown also found that the growth of sprouts was rapid.

Both Brickman and Brown studied the root system of alder and found it to be a spreading shallow system characterized by root nodules which are considered to be capable of nitrogen-fixation. This point should be emphasized since alder is one of the very few species in this region with this property. This ability may be quite a factor in the ecology of the species and its associates. In Europe, alder is interplanted with tree species on certain soils and results in a marked improvement in the growth of the trees.

Alder occurs naturally on productive soils which are difficult to manage properly and maintain in full production. Heavy cutting may convert such forest land into semi-swamp or marshland because of decreased transpiration and increased amounts of precipitation reaching the ground. This is especially true with conifers which have difficulty reproducing under heavy cover.

Species which reproduce by root suckers or sprouts have a decided advantage over other species on these soils. The forest manager would, however, prefer to grow the much more valuable spruce and balsam fir on these lands.

Conservative partial cuttings of the conifers are indicated by the danger of increased moisture content in the soil, vigor of competing weed vegetation, and danger of windfall. Heavier cuttings may result in the invasion of sphagnum, sedge, alder, willow and other swamp species. Wilde[4] mentions a study by LaFond that showed that the invasion of such sites by Carex and other swamp species leads to the development of a peculiar "sedge root moor" type of humus layer which is very unfavorable for the natural regeneration of the forest.

The desire to reforest alder areas with spruce must be tempered by the realization that this is a difficult process on some of the wetter soils supporting alder stands. Some sort of mound planting seems desirable; and competition of the alder and associated species, particularly grass and sedges, will require expensive followup work.

[4]Wilde, S. A.; F. G. Wilson and D. P. White (1949). Soils of Wisconsin in relation to Silviculture. Wis. Conserv. Dept. Pub. 525. 49 pp.

SUMMARY

Cutting of an alder stand, leaving a scattered stand of aspen and balsam poplar with nearby conifer seed trees, resulted in the appearance of some 416 stems of poplar per acre after 10 years. While 506 balsam fir seedlings appeared, only 32 per acre persisted to the end of the first 10-year period.

Girdling of half of the alder stand gave no advantage over untreated areas.

All cuttings of alder increased the grass and weed cover and made conditions less favorable to reproduction.

Cutting of a 10-year old stand of alder, aspen, and balsam poplar resulted in no increase in stocking of the more desirable species.

Cutting of a mature stand of well-stocked balsam poplar on the same site resulted in a full stocking of poplar which overtopped the alder sprout growth.

Other studies indicated that the invasion of alder on denuded areas by seed was slow and not a serious competitive factor, but that sprouting of established alder gave severe competition to all but the suckering and sprouting species.

More study is needed on the ecology of alder. Particular emphasis should be placed on methods to use in establishing conifer stands on these lands, and on the nitrogen-fixation ability of this species and its significance.

GIBBERELLIC ACID[1] AND HIGHER PLANTS:

I. GENERAL GROWTH RESPONSES

By M. J. BUKOVAC and S. H. WITTWER

Department of Horticulture

The remarkable plant growth-promoting properties of the gibberellins and gibberellic acid[1] have recently attracted the attention of American plant physiologists (Kahn et al., 1956; Lockhart, 1956; Marth et al., 1956; Phinney, 1956; Stodola, 1956; West and Phinney, 1956; and Wittwer et al., 1956).

Up to this year (1956), most reports on gibberellin have appeared in foreign (chiefly Japanese and English) journals. They were either overlooked or discounted by most American scientists. While papers have recently appeared describing the stimulatory effects of these substances on linear growth, especially of genetic (Brian and Hemming, 1955; Brian et al., 1954; Phinney, 1956a) or physiologic (Barton, 1956) dwarf plants, data on fresh weights and dry matter accumulations are notably lacking. The most detailed report of gibberellic acid effects on the latter growth criteria is that of Brian et al., (1954) for wheat and peas grown in solution cultures to which the growth substance was added.

Some of the remarkable effects of gibberellic acid on the growth and development of plants with possible horticulture applications will be presented in this series.

PROCEDURE

All greenhouse experiments were conducted during the spring and summer when moderate temperatures (55 to 65°F. at night and 80 to 95 F. during daylight), long days, and generally good sunlight pre-

[1]The gibberellins used in these studies consisted of a mixture of gibberellins A and X (gibberellic acid) having rotation values of $[\alpha]_D$ + 62 to + 75 and gibberellic acid $[\alpha]_D$ + 92, supplied by Dr. F. H. Stodola, Northern Regional Research Laboratories, U. S. Department of Agriculture, Peoria, Ill. No differences, qualitative or quantitative in growth responses among the various gibberellin preparations have thus far been detected. Thus "gibberellic acid" is often used for brevity in the text which follows.

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vailed. Both soil and solution (standard Hoagland) cultures were utilized. High levels of nutrition were maintained in the soil cultures by frequent fertilization with diammonium and monopotassium phosphates; the solution cultures were frequently renewed.

Aqueous stock solutions containing the gibberellins were prepared as needed, and quantities approximating 0.01 ml. of a known concen-

Fig. 1. Comparative growth of pea varieties 3 weeks after treating the second unfolding leaf with 20 micrograms of gibberellin. Plants in alternate cultures treated. Top, Little Marvel; bottom, Alderman.

TABLE 1—Growth responses of pea varieties to gibberellin 3 weeks after applying 20 micrograms to the surface of the second leaf as it was unfolding (each value a mean of three replications of five plants each)

Variety	Treatment with gibberellin	Growth measurement			
		Height	Fresh weight of tops	Fresh weight of roots	Shoot-root ratio
		(cm.)	(gm.)	(gm.)	
Little Marvel	−	32.0	11.84	5.84	2.03
	+	92.4	11.54	4.86	2.37
Greater Progress	−	26.8	12.64	7.64	1.65
	+	79.0	10.32	4.98	2.07
Alderman	−	76.0	12.67	6.48	1.96
	+	100.2	13.64	5.78	2.36
Freezonian	−	91.0	15.16	6.26	2.42
	+	100.0	12.60	5.29	2.38
L.S.D.*—5 percent	..	13.2	No	1.69	....
—1 percent	..	19.2	significance	2.45	....

*Least significant difference.

tration were delivered from a micropipette onto the growing tip (stem apex) or the surface of the youngest unfolding leaf.

Plant heights were determined by using the position on the stem of the cotyledons as a base and measuring to the growing tip of greatest vegetative extension. Fresh weights were determined immediately after harvest; dry weights were taken after dehydration of the plant materials at 70°C. in a forced air oven. F tests for differences between treatment means are presented when applicable as least significant differences (L.S.D.) at the 1 and 5 percent levels.

RESULTS

Peas

In terms of vegetative extension, the plants most responsive to gibberellic acid are the genetically dwarf types. This is shown by a comparison of the data in Table 1, and it is illustrated in Fig. 1 for well-known dwarf and tall varieties of peas grown in solution cultures. Each treated plant received a single application of 20 micrograms of gibberellin to the surface of the second leaf as it was unfolding.

Differences in growth following treatment were apparent within

24 hours. Three weeks after treatment, the very dwarf variety Little Marvel outgrew in height the nontreated tall Alderman (Fig. 1). In general, this confirms the work of Brian and Hemming (1955) for English varieties. All pea varieties responded to gibberellic acid by an increase in vegetative extension, but the most pronounced effects were with dwarf types.

There were no differences in flowering time or the node at which the first flowers appeared following treatment. Likewise, after 3 weeks,

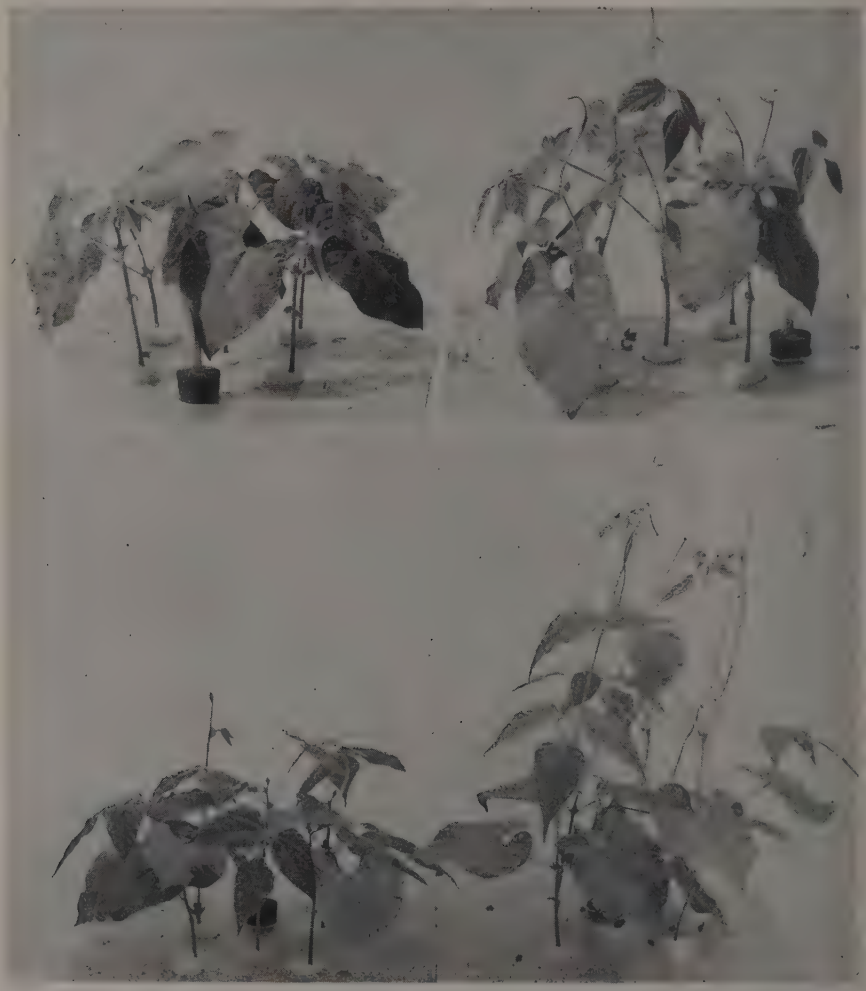

Fig. 2. Response of Contender bean plants in solution culture 48 (top) and 96 (bottom) hours after application of 20 micrograms of gibberellin to the stem apices. Left, control; right, treated.

TABLE 2—Growth responses after 30 days of bean varieties with various amounts of gibberellin applied to the growing tip when the two primary leaves were expanded (each value a mean of five replications of three plants each)

Variety	Plant heights (inches)				Dry weights (gm.)			
	(micrograms of gibberellin per plant)							
	0	5	10	20	0	5	10	20
Contender	14.6	39.3	38.2	50.8	4.8	5.0	4.6	4.4
Rival	16.4	34.3	41.4	37.8	6.3	6.2	5.2	6.3
Blue Lake	59.0	68.0	88.6	70.6	3.8	3.6	3.6	3.6
Treatment means	30.0	47.2	56.1	53.1	5.0	4.9	4.5	4.8
L.S.D.—5 percent	7.6				No significance			
—1 percent	10.1							

there were no significant differences in the fresh weights of tops (Table 1). Root growth (fresh weight) was less in all varieties receiving gibberellin, with a highly significant reduction for Greater Progress. This, in turn, was reflected in a higher shoot-root ratio for all varieties except Freezonian.

Beans

As with peas, a single application of 10 to 20 micrograms of gibberellin a few days after seedling emergence resulted in a continuous stimulation of growth. This persisted for several weeks. With bush varieties such as Contender or Bountiful, the response was remarkable. Lateral branching was retarded, the main axis grew very rapidly, long internodes developed, and the resultant twining vines appeared as pole beans within 2 to 4 days. Vegetative extensions of 6 to 8 inches a day were not unusual (Fig. 2).

Table 2 presents the effects of various amounts of gibberellin on Contender (bush type), Rival (semibush), and Blue Lake (pole type) beans grown in soil cultures. Although marked differences in heights resulted, there were no differences in dry weights of tops. The amounts of the chemical needed for maximum vegetative extension were somewhat higher for the bush than the pole type beans.

In solution cultures, a marked elongation of the epicotyl appeared in the Blue Lake bean, varying according to the amounts of gibberellin applied (Table 3). However, no significant differences in dry weights

of either tops or roots, or in root extension of this plant grown in solution cultures, have been detected.

Of particular interest, however, is the sensitivity of the variety Blue Lake[2] to gibberellic acid. As shown in Fig. 3, it responded in epicotyl growth (height) to as little as 0.01 micrograms per plant; maximum vegetative extension occurred at about 10 micrograms even if larger amounts were applied. This variety has served as a useful bioassay for various gibberellin preparations.

The rapidity of response and sensitivity of the Blue Lake bean to gibberellic acid is influenced by the age (size) of the plants when treated. Epicotyl heights 3, 6, and 8 days after treatment of plants at different ages (5 to 13 days from seeding) are plotted in Fig. 4. A pronounced growth stimulation followed treatment in all plants regardless of age, but the most immediate increase in elongation was with plants having fully expanded primary leaves (9 to 11 days from seeding).

Thus, age (more appropriately, the stage of plant development when treated) is an important consideration in developing a sensitive bioassay for gibberellins. It is equally important in a proper evaluation of potential growth responses.

As a supplement to the study of general growth responses induced by gibberellin, its effect on overcoming the growth reduction of bean (var. Blue Lake) epicotyls after treatment with maleic hydrazide was studied. Plants were sprayed with four concentrations of maleic hydrazide during the expansion of the primary leaves. One hour later, the tips

[2]Black seeded type, Stock No. 42335, Rogers Bros. Seed Co., Idaho Falls, Idaho.

TABLE 3—The effect of various amounts of gibberellin and days after treatment on the heights and dry weights of Blue Lake beans grown in solution cultures (each value a mean of 10 single plant replications)

Gibberellin per plant (μg)	Epicotyl heights (cm.)			Dry weights (gm.)			
				Tops		Roots	
	(Days after treatment)						
	3	6	12	6	12	6	12
0.00 (control) .	4	18	65	.26	.96	.08	.15
0.02.....	13	33	70	.27	1.01	.07	.17
0.20.....	15	55	96	.27	.96	.06	.15
2.00.....	18	61	120	.31	.96	.07	.14
20.00.....	18	63	123	.32	1.03	.08	.14

Fig. 3. Growth responses of beans (var. Blue Lake) to various amounts of a mixture of gibberellin A and X, 120 hours after treatment.

Left to right:

μ/g plant	100	50	25	10	5	2	1	0.5	.25	.10	.05	.02	.01	.00
Height in cm.	42	42	43	43	43	35	31	28	21	16	13	11	9	7

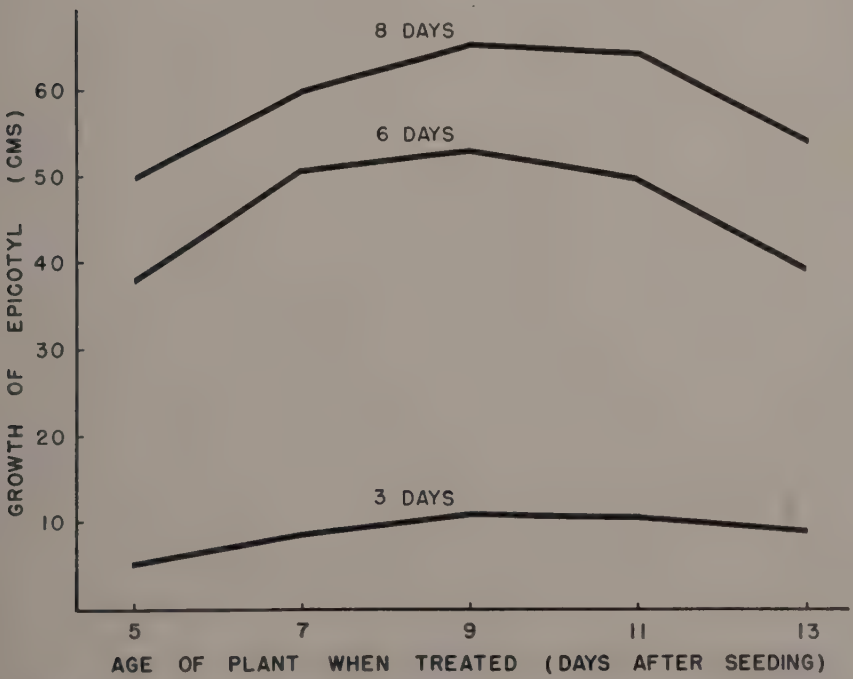

Fig. 4. Comparative growth responses to Gibberellin (20 micrograms per plant) applied to the epicotyl tips of Blue Lake beans at different dates after seeding. Increases in epicotyl length are plotted for 3, 6 and 8 days after treatment.

of the epicotyls were treated with three levels of gibberellin. The extension of new growth was subsequently measured at 24-hour intervals (Table 4).

With one exception (maleic hydrazide at 1,000 p.p.m. 96 hours after treatment) gibberellin overcame the inhibitory effects of maleic hydrazide on epicotyl growth. Likewise, growth inhibition of bean epicotyls following treatment with α-cyano-β(2,4-dichlorophenyl) acrylic acid (500 to 2,000 p.p.m.) was overcome by gibberellin. Thus, these two chemicals had opposite effects to that of gibberellin on the

TABLE 4—Effect of gibberellin on the growth (24-hour increments in centimeters) of maleic hydrazide treated beans (var. Blue Lake)

Time interval between treatment with gibberellin and harvest (hours)	Gibberellin (μg/plant)	Maleic hydrazide (p.p.m.)			
		0	100	500	1,000
24	0	.3	.2	.2	.1
	10	.3	.9	.6	.6
	100	.8	.8	.6	.6
48	0	.5	.2	.3	.3
	10	2.3	1.9	1.7	1.4
	100	2.6	2.0	1.6	1.3
72	0	.5	.7	.6	.4
	10	6.5	5.1	2.0	1.2
	100	7.6	5.9	2.1	1.4
96	0	.9	.8	.3	.2
	10	13.0	9.6	1.0	.4
	100	14.7	11.0	.8	.7

Subtable

GROWTH INCREMENT MEANS FOR ALL TIME INTERVALS

Gibberellin (μg/plant)	Maleic hydrazide (p.p.m.)			
	0	100	500	1,000
0	.6	.5	.4	.3
10	5.5	4.4	1.3	.9
100	6.4	4.9	1.3	1.0
L.S.D. for growth means for all times—5 percent	0.5			
—1 percent	0.7			

TABLE 5—The effect of gibberellin (0, 10 and 20 micrograms per plant) on heights and dry weights of tops of several tomato varieties (each value a mean of five single plant replications)

Variety	Plant heights (cm.)			Dry weight of tops (gm.)		
	(Micrograms of gibberellin per plant)					
	0	10	20	0	10	20
PI—205046* (very dwarf)	18	29	29	6.4	13.9	7.7
Early Chatham	58	68	74	19.3	19.4	20.4
Moreton Hybrid	63	75	74	21.1	19.4	19.4
Stokesdale	54	72	73	18.7	21.6	19.9
Rutgers	55	69	71	19.1	17.7	16.6
L.S.D. for comparing concentration effects on any variety—5 percent		6			No significance	
—1 percent		8				

*Seed supplied by M. M. Hoover, Regional Plant Introduction Station, Horticultural Crops Research Branch, Ames, Iowa.

growth of the main axis. Similar relationships for maleic hydrazide were implied by Kato (1956) but no data were given.

Tomatoes

Five tomato varieties were grown in soil cultures. The comparative heights and dry weights of tops were recorded 40 days after the first gibberellin application. All treated plants received 10 micrograms of gibberellin on the plumule leaves just as they were emerging. In turn, half of these received 10 more micrograms 1 week later. Thus, along with those plants receiving no gibberellin, the 10 and 20 microgram levels indicated in Table 5 were achieved. Varieties treated ranged from the very dwarf determinate PI-205046 to the highly vigorous indeterminate Rutgers. As with other crops, a striking increase in plant heights for all varieties resulted from 10 or 20 micrograms of gibberellin. Some increase in dry weights of tops was apparent with PI-205046 and Stokesdale at the 10 microgram level (Table 5).

Celery

Of the many varied growth responses after treatment with gibberellic acid, the most commercially promising are those with celery. When grown in soil cultures in the greenhouse and treated at various developmental stages relative to leaf numbers, the variety Cornell 19 showed remarkable increases in height, petiole length, and fresh and

dry weights of tops (Table 6). A single (20 μg) dose to the young (three- to four-leaf stage) plants and repeated applications (40μg) to older plants (10 to 12 leaves) gave the greatest weight increases.

Differences approximating a 50 percent increase in yield occurred, however, regardless of treating pattern or leaf number when treated. Treated plants were normal except for the pronounced acceleration in growth of tops.

Other varieties, Utah 10-B, Utah 52-70, Summer Pascal (Waltham strain) and Golden Detroit (Plume type) showed similar responses both in pot cultures in the greenhouse and when grown on muck soil in the field (Fig. 5).

Other Crops

Numerous crops have been treated with gibberellin in the early seedling stages and at intervals thereafter. Head lettuce, leaf lettuce, and cabbage responded by a rapid elongation of a normally telescoped stem (Wittwer, Bukovac, Sell and Weller, 1956). Heights of pepper plants were doubled or tripled. The leaves grew larger and the internodes longer in summer squash and cucumbers. When treated

TABLE 6—Growth responses of celery (var. Cornell 19) to 20 and 40 micrograms per plant of gibberellin applied at various stages of plant development (each value a mean of 10 single plant replications)

Leaf number when treated	Times treated	Gibberellin applied	Time between first treatment and harvest	Total height	Petiole length	Fresh weight of tops	Dry weight of tops
		(μg/plant)	(days)	(cm.)	(cm.)	(gm.)	(gm.)
3-4.....	1	20	31	27.3	13.2	34.0	3.7
	2	40	..	27.7	13.3	30.8	3.1
6-7.....	1	20	22	27.7	13.3	32.8	3.4
	2	40	..	31.0	14.2	33.1	3.3
10-12.....	1	20	14	28.2	13.2	33.3	3.1
	2	40	..	30.7	13.7	38.8	3.6
	Control (no treatment)	..	..	17.0	7.0	21.6	2.3
L.S.D.—5 percent.....			..	2.6	1.8	5.0	0.6
—1 percent.....			..	3.5	2.4	6.8	0.8

Fig. 5—Increased growth of field grown celery (var. Utah 10-B) following treatment with gibberellin. Left, first 10 plants in the row treated with 20 micrograms per plant at the 10-leaf and again at the 15-leaf stage; right, controls (no treatment). Insert (left): growth 2 weeks following application of 20 micrograms of gibberellin at the three- to four-leaf stage; (right) control.

(10 to 20 μg per plant) shortly after emergence by dropping the chemical solution into the leaf whorl, sweet corn seedlings (var. North Star and Golden Cross) doubled in height within 72 hours; however, growth leveled-off within a few days and was again comparable to non-treated plants.

It is expected that the most favorable growth responses of plants to gibberellic acid will be realized under specific conditions of mineral nutrition (Brian et al., 1954, light (Lona, 1956; and Lona and Bocchi, 1956), and temperature (Krofranek and Phinney, 1956; Lang, 1956a; and Lang, 1956b).

DISCUSSION

All crops thus far treated have responded to gibberellic acid by increased vegetative extension. In most cases, the increased growth seems normal. There is apparently greater elongation of young and

growing cells in stems, internodes, and leaves. In general, stems are thinner; leaves are broader and lighter green in color.

The most responsive crops so far have been dwarf peas and bush type beans where dwarfism is overcome. While increases in vegetative extension have been highly significant after treatment with gibberellic acid, there were no differences in fresh or dry weights. Celery was an important exception; yields of tops were increased by more than 50 percent.

Undoubtedly, other leafy vegetables and many forage crops also grown primarily for their vegetation would show comparable growth differences. It appears that larger dosages, properly repeated and timed, offer many possibilities to increase crop production.

The experiments outlined here emphasize that important factors controlling plant response to gibberellic acid include the stage of growth when treated, the quantity applied, and the treating pattern. Brian, et al., (1954) added gibberellic acid (1 to 10 μg/ml) to solution cultures; he obtained significant increases in fresh and dry weights and in carbon assimilation of pea and wheat seedlings. His method of application (i.e., to the roots) offered a continuous supply for plant growth; this may partly explain the differences between Brian's results and those reported here where somewhat larger amounts were applied as single doses to the vegetative apex.

SUMMARY

Gibberellic acid or gibberellin (10 to 20 micrograms per plant) was applied to peas, beans, tomatoes, peppers, sweet corn, summer squash, cucumbers, lettuce, and cabbage, grown in soil or solution cultures in the greenhouse. It induced marked elongation of internodes and often caused the leaves to broaden or elongate. There were some accompanying increases in fresh and dry weights of tops, but root growth decreased correspondingly.

The most striking responses thus far observed have been with bush beans which, when treated, form twining vines and grow as pole types; dwarf peas that grow taller than normal tall types; and leaf and head lettuce in which the stems immediately elongate and no leaf rosette or head is formed.

With celery (in early stages of growth both in the greenhouse and field), plant heights and petiole lengths were almost doubled, and fresh and dry weights increased by about 50 percent.

Bean seedlings (var. Blue Lake) responded to concentrations of

gibberellin ranging from 0.01 to 100 micrograms per plant by increased linear growth of epicotyls. Consequently, they are useful as a bio-assay for gibberellin preparations. In growth control of the epicotyl, gibberellic acid had an effect opposite to that of maleic hydrazide. It either reduced or completely overcame maleic hydrazide-induced inhibitions of linear growth.

Many factors, including species, variety, mineral nutrition, light, temperature, age of plant (leaf number) when treated, treatment pattern, site of application, and dosage, influence plant response to gibberellic acid.

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STUDIES IN HATCHABILITY

II. THE PERFORMANCE OF TWO STRAINS OF LEGHORNS IN INTER AND INTRA-STRAIN MATINGS

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Hatchability[1], a rather complex biological expression of the fowl, has commanded the attention of poultry investigators for many decades. Commercially, the economic importance of obtaining high hatchability is well-recognized. A relatively safe estimate appears to be that, on a national average, approximately one chick in five fertile eggs fails to hatch.

A survey of the literature points to general agreement that hatchability is an heritable trait, rather low in calculated magnitude. The calculated estimates for the heritability of hatchability as reported by Shoffner and Sloan (1948) was 0.16 and 0.10 by Wilson (1948). Both heritability estimates were adjusted for inbreeding.

Further, hatchability is known to be complex in mode of inheritance, and readily influenced by non-genetic as well as genetic factors. The inter-relationship between hatchability and such traits as egg size, egg shape, shell quality, and others is also recognized. Despite the intimate relationship between the genetic factors and environmental factors involved, poultry breeders are striving to increase the frequency of desirable hatchability genes through various systems of breeding.

A wealth of information is available on the effects of inbreeding, crossbreeding, top crossing, incrossing, etc., on hatchability. In recent years, there has been considerable interest in the effects of strain crossing. That strain crossing may or may not result in a stimulation in hatchability is well-recognized.

Hutt and Cole (1951, 1952) made reciprocal crosses of two strains of White Leghorns, producing F_1 inter and intra-strain offspring from

[1]Hatchability as used herein refers to chicks from fertile eggs.

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each of nine males. A consistent stimulation (approximately 5 percent) in the hatchability of the eggs produced by the individuals in the inter-strain matings was observed, although both strains of Leghorns had a low coefficient of inbreeding. A preliminary report on the hatchability of eggs produced by two strains of S. C. White Leghorns in reciprocal strain-cross matings was presented by Champion (1955). Also, hatchability data on limited numbers of eggs produced by F_1 inter-strain hybrid females backcrossed to males of the pure strains were reported. Heterosis for hatchability was not observed in the eggs produced by the reciprocally mated non-inbred pure strain individuals used. However, numbers of eggs set and numbers of individuals tested were small.

Hatchability data on the eggs produced by non-inbred S. C. W. Leghorn females in inter and intra-strain matings are reported in this investigation.

EXPERIMENTAL PROCEDURE

The pedigreed individuals of the two strains of Single Comb White Leghorns used in this investigation were the progenies from selected individuals, the original strains of which were procured from two Leghorn breeders. For identification purposes, the two strains are hereinafter designated as Strain A and Strain B, corresponding to those reported by Champion (1955).

The symbolical designations of the matings to produce the inter and intra-strain hatching eggs and progenies are: Strain A male on Strains B and A females; and Strain B male on Strains A and B females. Nine different Strain A males were mated concurrently with Strain A and Strain B females, and nine different Strain B males were mated concurrently with Strain B and Strain A females. Therefore, each male sired both inter and intra-strain progeny. The individuals of the two strains tested were non-inbred.

Managerial techniques for the trapnested parental birds were standardized. An all-mash breeder ration was fed *ad libitum* and a special elevated feed hopper containing cereal grains was available to supplement the ration of the males. Fresh water and oyster shell were constantly available.

All eggs were pedigreed and incubated at weekly intervals in a forced-draft incubator during the months of February to May, inclusive. All eggs were candled on the 18th day of incubation; all infertile eggs and dead germs were removed and broken-out to macroscopically

confirm candling-light results. The usual procedures for pedigree-basketing and taking-off the hatches of chicks were followed.

The data, singly and in combination, were analyzed by chi-square (Pearson, 1900), with modifications as to the numbers of degrees of freedom as established by Fisher (1922). This method employs the use of 2 x 2 tables for disproportionate sub-class numbers and the values of chi-square are for one degree of freedom.

EXPERIMENTAL RESULTS AND DISCUSSION

The 80 Strain A females, mated to each of nine Strain A males, produced 792 fertile eggs which had a hatchability of 90.28 percent (Table 1). The 41 Strain B females, mated to the same nine Strain A males, produced 579 fertile eggs which had a hatchability of 93.78 percent. The difference of 3.50 percent hatchability in favor of the F_1 inter-strain hybrid embryos was highly significant ($P = < 0.01^{**}$). From these data, it may be concluded that the F_1 inter-strain hybrid embryos, F_1 (A x B), demonstrated the influence of heterosis for hatchability over their intra-strain half-sib embryos.

In the reciprocal inter and intra-strain crosses, the 161 Strain B females, mated to each of nine Strain B males, produced 2,523 fertile eggs which had a hatchability of 87.71 percent. The 54 Strain A females, mated to the same nine Strain B males, produced 598 fertile eggs, the hatchability of which was 94.82 percent. The difference in hatchability of 7.11 percent in favor of the F_1 inter-strain hybrid embryos, F_1(B x A), was highly significant ($P = < 0.01^{**}$) (See Table 1). Similarly to the reciprocal inter-strain cross embryos (A x B), the B x A strain cross embryos showed a consistent improvement in hatchability over their intra-strain half-sibs.

Therefore, the embryos produced by the individuals in reciprocal inter-strain matings showed a highly significant stimulation in hatchability over their intra-strain, half-sib embryos (Table 1).

In the total picture, the F_1 (A x B) inter-strain hybrids excelled the pure line A x A in hatchability by 3.50 percent; the reciprocal F_1 inter-strain hybrids, F_1(B x A), excelled the pure line B x B in hatchability by 7.11 percent. This heterosis for hatchability of F_1 inter-strain hybrids agrees with the findings previously reported by Hutt and Cole (1951, 1952).

*Significant at the 0.05 percent level.
**Significant at the 0.01 percent level.

Statistical comparisons were also made between the hatchability of the eggs produced by the individuals in the two kinds of intra-strain matings, A x A and B x B. A total of 715 chicks were hatched from the 792 fertile eggs produced by the individuals in the intra-strain A matings for a hatchability of 90.28 percent. The hatchability of the eggs from the intra-strain B individuals was 87.71 percent (2,213 chicks from 2,523 eggs). The difference in hatchability of the two kinds of embryos from the individuals in intra-strain matings was significant ($P = < 0.05^*$) (Table 1).

The hatchability of the two kinds of F_1 inter-strain hybrid embryos was also compared. The hatchability of the F_1 (A x B) embryos (93.78 percent for 579 eggs) did not differ significantly from the hatchability of the F_1 (B x A) embryos (94.82 percent for 598 eggs). These data indicate that, regardless of the direction of the cross of the parental strains (i.e., Strain A males on Strain B females or Strain B males on

TABLE 1—The hatchability of eggs produced by individuals in inter and intra-strain matings

Mating	Numbers of males tested	Numbers of females tested	Fertile eggs	Chicks hatched	Hatchability percent	X^2	P
A ♂ x B ♀	9	80	792	715	90.28	12.621	<0.01**
		41	579	543	93.78		
B ♂ x A ♀	9	161	2,523	2,213	87.71	25.016	<0.01**
		54	598	567	94.82		
A x A	9	80	792	715	90.28	3.864	0.05*
B x B	9	161	2,523	2,213	87.71		
A x B	9	41	579	543	93.78	0.239	0.64
B x A	9	54	598	567	94.82		
A x A	9	80	792	715	90.28	11.369	<0.01**
All F_1's	18	95	1,177	1,100	94.30		
B x B	9	161	2,523	2,213	87.71	38.106	<0.01**
All F_1's	18	95	1,177	1,100	94.30		

*Significant at 0.05 percent level.
**Significant at 0.01 percent level.

Strain A females), the two kinds of F_1 inter-strain hybrid embryos had comparable hatchabilities. These results are interpreted to indicate that, although the two pure strains differed significantly in hatchability, the dams had little, if any, more influence on hatchability than did the sires.

As no significant differences in hatchability were found between inter-strain F_1 hybrid embryos, these hatchability data were pooled and compared with the hatchability data from the two intra-strain populations (Table 1). In summary, highly significant improvements ($P = < 0.01^{**}$) in hatchability were observed in both kinds of inter-strain F_1 hybrid embryos—F_1 (A x B) and F_1 (B x A)—over the pure line—A x A and B x B—embryos. These data indicate that a stimulation or heterosis in hatchability occurred when the two particular strains of S. C. White Leghorns used in the investigation were reciprocally mated, despite the relatively high hatchability of the eggs from individuals in the intra-strain matings (Strain A—90.28 percent; Strain B—87.71 percent).

As previously indicated, the preliminary strain-crossing tests by Champion (1955) did not show heterosis for hatchability. The disparity in the 1955 results from those reported here may be explained, in part, by the small numbers of individuals and fertile eggs involved in the earlier study. Further, a more critical experimental design which involved concurrent matings was used in this test. An additional important consideration (as pointed out by Landauer, 1948) is that the breeding system *per se* does not determine whether heterosis may occur; but rather the genotypic constitution of the parental stocks. The birds used in this investigation were cockerels and pullets and, therefore, represented a new generation of individuals.

SUMMARY

Two strains of non-inbred S. C. White Leghorns were used in inter and intra-strain matings. Nine different Strain A males and nine different Strain B males were tested. The following results were obtained:

1. The embryos from the individuals in the two pure parental lines differed to a significant degree in hatchability.
2. The two kinds of F_1 inter-strain hybrid embryos did not differ significantly in hatchability.
3. Reciprocal F_1 inter-strain hybrid embryos showed a consistent

and highly significant stimulation in hatchability when compared with their intra-strain, half-sib embryos.

4. Evidence of maternal effects on hatchability was not obtained.

Thus, the effects of heterosis on hatchability were demonstrated by inter-strain embryos from the individuals of the particular population investigated.

The importance of making test crosses between strains for combinability or "nicking" for any single trait or combination of characteristics is emphasized.

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CONSUMERS' OPINIONS OF QUALITY IN PORK CHOPS

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HAS THE AVERAGE consumer been consulted often enough in establishing quality standards for many agricultural products? To measure consumers' ability and willingness to distinguish quality levels, a consumer preference panel was recruited in Detroit.

The panel met in the Home Economics Laboratory at Wayne State University once a month from January through May of 1956. About 125 consumers attended each session. They were given an opportunity to rate the products displayed, including poultry, eggs, apples, potatoes, and pork chops.

This report deals with the ranking of different quality pork chops. Several series of pork chop samples were set up to reflect such characteristics as color, fat covering, and kind of chop.

METHOD OF SELECTING PANEL MEMBERS

Panel members were selected as follows: Mail questionnaires were sent to about 6,500 names obtained from the latest Detroit telephone directory. About 5 percent of these were returned by the post office for nondelivery. About 20 percent of the remainder were filled out and returned either from the first or followup questionnaire.

The basic questions asked concerned age group, education group, income group, and willingness to come to a display room in Detroit to rate samples of the different products displayed. A majority of those selected for the panel were in the middle income group, had received a high school education, and were in the 31 to 45 age group.

Those who returned questionnaires and who were willing to take

[1]Thanks are due L. J. Bratzler of the animal husbandry department, Michigan State University, for the preparation of the various samples of pork chops; and Mrs. M. J. Bostick and Mrs. F. G. Sanderson of the home economics department at Wayne State University for their help in planning the panel meetings.

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part in the panel were contacted by telephone to schedule their visit and to inform them of the method of remuneration.

PANEL PROCEDURE

Panel meetings were conducted from 2 o'clock in the afternoon until 10 o'clock in the evening. After a briefing on the general purpose of the project, panel members were asked to rank the samples in each series independently of the other series. Except where indicated otherwise, the ranking was to be based on the order in which they would select the various samples if they were getting them, regardless of price.

Symbols were used to link the actual samples with the ranking on the panel report cards so that numerical or alphabetical order would not influence selection. The symbols were alternated so that a particular figure would not continually indicate a certain quality. The positions of the products on display were also varied in order that the highest quality would not be placed in a standard position. The symbols used were #, %, &, *, and ().

The samples were prepared in the animal husbandry department of Michigan State University under the direction of L. J. Bratzler. The pork chops were wrapped in cellophane, a common practice in retail food stores, and displayed in iced trays.

SCORING METHOD

For ease of analysis, a preference score was calculated for each sample. The percentage of total first rankings, second rankings, etc., in each test or series was determined for each sample. This percentage for first ranking was multiplied by five for each sample. The percentage for second ranking was multiplied by four, and so on in descending order. These adjusted percentages were added to give a single preference score for that sample.

The highest score in each series indicates the sample that was preferred by the largest number of panel members. The amount of differences between the scores shows the degree of preference for samples.

GENERAL QUALITIES OF PORK CHOPS

The first series of chops was made up of five samples. One sample was used as a control; it had no defects according to standards com-

TABLE 1—Ranking by general qualities of pork chops, January 1956

Description of sample	Ranking					Preference score
	1st	2nd	3rd	4th	5th	
	No. of people ranking each sample					
No defect	15	36	33	18	21	295.7
Inferior in marbling	9	13	19	41	41	225.3
Inferior in size of eye	10	17	28	40	26	247.0
Inferior in color	76	17	8	16	6	394.3
Inferior in firmness	20	50	35	13	5	338.4

monly used by experts in judging the quality of pork chops. The other four samples were of comparable quality except for the specific defect listed for the samples.

Table 1 indicates the ability of panel members to distinguish generally established characteristics of quality and also the extent of agreement among themselves as a group regarding quality. The sample without defect was ranked first by only 15 people and fifth by 21 people. The preference score for the group showed this chop as the third choice. In this instance, the panel did not object to the color defect and apparently lowered the ranking of the control sample because of a defect not considered by the experts.

This series was repeated the following month with results as shown in Table 2.

The above two tables show that the consumers were not entirely consistent in their choices. For example, in January the panel members selected the chop that was inferior in color. In February, a similar chop was the fifth choice.

TABLE 2—Ranking by general qualities of pork chops, February 1956

Description of sample	Preference score
No defect	317.8
Inferior in marbling	306.7
Inferior in size of eye	299.0
Inferior in color	197.0
Inferior in firmness	379.5

FAT COVERING OF PORK CHOPS

In another series, fat covering was the only variable. In this series, uniform quality chops had fat covering variations ranging from no fat to ½ inch.

As shown in Table 3, the panel members in both months showed a fairly strong preference for the chops with ⅛-inch fat covering. There was no strong preference among the no fat, ¼-inch and ⅜-inch samples, but the ½-inch fat cover chops were decidedly less favorable to the panel.

TABLE 3—Ranking by fat cover of pork chops, January and February 1956

Sample description	Preference score	
	January	February
No fat	301.5	308.8
⅛-in. fat cover	360.6	403.6
¼-in. fat cover	300.1	291.9
⅜-in. fat cover	291.0	320.0
½-in. fat cover	246.1	175.7

COLOR AND FAT COVERING

A third series of chops had two variables, color and fat covering. The good color chops selected for the samples were grayish-pink. The poor color chops were darker and showed less marbling.

As can be seen in Table 4, the first choice in March was for the poor colored chops with ⅛-inch fat cover, followed by the good colored chops with ⅛-inch fat cover; the samples with ⅜-inch fat cover ranked last.

TABLE 4—Ranking by color and fat cover, March and April 1956

Sample description	Preference score	
	March	April
Good color: ⅛-in. fat cover	379.5	462.6
Poor color: ⅛-in. fat cover	396.1	350.6
Good color: ⅜-in. fat cover	297.8	344.7
Poor color: ⅜-in. fat cover	326.9	242.4

These results were almost reversed in April when the consumers showed a strong preference for the samples with good color and ⅛-inch fat cover. Difficulty in obtaining chops with exactly the same color distinctions in the different months might explain some of the apparent inconsistencies of the panel members.

COLOR, FAT COVER, AND PRICE

A third factor, price, was then added to the color and fat cover factors, and a comparison was made between the panel members' selections with and without a price difference (Table 5).

When the price differential was applied, the consumers tended to shift their preference to the poor colored chops at 2 cents a pound less. However, the preference for ⅜-inch fat covering with comparable color at 3 cents a pound less was mixed. On the basis of this limited test, housewives would be likely to pay a premium for the desirable fat covering but not for the better color.

TABLE 5—Ranking by color, fat cover, and price, May 1956

Sample description	Preference score
Good color: ⅛-in. fat cover—70c lb....	251.2
Poor color: ⅛-in. fat cover—68c lb....	427.3
Good color: ⅜-in fat cover—67c lb....	305.2
Poor color: ⅜-in. fat cover—65c lb....	416.3

KINDS OF PORK CHOPS

Another series consisting of different kinds of chops was displayed for 2 consecutive months.

In both months, the center cut loin chops were the first choice and the blade cuts the last choice of the panel members. Differences in

TABLE 6—Ranking by kinds of pork chops, January and February 1956

Sample description	Weighted percentage	
	January	February
Center cut—loin	423.2	424.7
Center cut—rib	391.1	354.1
Sirloin	363.1	388.5
Blade	223.3	233.1

TABLE 7—Rankings by general qualities of pork chops by income groups, January 1956

Sample description	Preference score by income groups			
	1	2	3	4
No defects	350.5	282.3	237.8	309.1
Inferior marbling	163.4	259.7	243.8	200.9
Inferior size of eye	197.3	272.6	249.8	269.2
Inferior color	440.4	385.7	394.2	390.3
Inferior firmness	348.4	304.6	379.9	330.5

choice between the center-cut rib and the sirloin chops were small (Table 6).

INCOME GROUPS[2]

To determine whether or not a relationship existed between income group and panel preference, the preferences submitted by the panel members were divided into major income groups, and their selections were summarized (Table 7).

Rating by the different income groups appeared to be quite similar to the panel as a whole. The first income group ($2,000-$4,000) showed a wider range in choice of samples, as shown by larger differences in the preference scores, than did the other groups. However, this cannot be described as an income characteristic, as income group 2 ($4,001 to $5,400) showed the least spread of preference of the four groups.

A breakdown by income group of the panel members' preference for fat covering is given in Table 8. The ⅛-inch fat covering was first

[2]Most of the panel members were in one of the following income groups: Group 1: $2,000 to $4,000 (total 17 panel members); Group 2: $4,001 to $5,400 (total of 25); Group 3: $5,401 to $7,000 (total of 27); Group 4: $7,001 to $10,000 (total of 20).

TABLE 8—Ranking by fat cover, February 1956

Sample description	Preference score by income groups			
	1	2	3	4
No fat	230.0	313.2	304.5	325.7
⅛-inch fat cover	446.7	386.2	385.7	456.1
¼-inch fat cover	343.7	314.3	314.1	265.5
⅜-inch fat cover	313.3	313.3	302.6	299.6
½-inch fat cover	166.7	172.9	193.0	153.1

choice and the ½-inch fat cover sample the fifth choice of each of the four income groups. Less difference can be noted in the scores of the other three samples, except that the no fat sample had a considerably lower score by income group 1 than by the others.

In April, a breakdown by income group was made for rankings by color and fat cover (Table 9). Rankings by groups were similar to those of the entire panel (Table 4).

When price differentials were added to a comparable series, the rankings by individual groups also were similar to the entire panel.

TABLE 9—Ranking by color and fat cover, April 1956

Sample description	Preference score by income groups			
	1	2	3	4
Good color: ⅛-in. fat cover.....	449.6	443.6	479.2	450.7
Poor color: ⅛-in. fat cover.....	384.0	349.8	334.7	359.5
Good color: ⅜-in. fat cover.....	323.3	353.8	359.0	347.4
Poor color: ⅜-in. fat cover.....	243.1	252.8	227.1	242.3

SUMMARY

Since this article is a progress report, many of the reported findings will be subjected to repeated tests and more elaborate statistical analysis. The preliminary results, however, indicate the following facts about the choices made by the panel groups.

1. Kind of chop, amount of fat cover, and color were the major factors used by the panel in selecting pork chops.

2. A consumer's choice was sometimes made on the basis of a factor or a combination of factors not considered here.

3. The application of price differentials to some of the samples changed the choices of the panel members.

4. Individual income groups' (admittedly too small for definite conclusions) choices were similar to those of the entire panel.

SOIL MOISTURE USED BY ORCHARD SODS

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DURING THE PAST 25 years, sod culture has gradually replaced clean culture in many Michigan commercial apple orchards growing on the heavier and deeper types of soil. Factors influencing this change include better control of soil erosion, decreased surface runoff, and ease of handling the soil.

In addition, the sod cover has effectively withstood the travel of heavy spray equipment in the spring when the soil was saturated with water. This makes it possible to apply early sprays with less difficulty and delay.

In changing from clean culture to sod in these orchards, various grasses, legumes, and grass-legume sods were established. They included Kentucky bluegrass, Chewing's fescue, redtop, timothy, white or red clovers, alfalfa, and combinations of some of these. In some orchards, quackgrass and other grasses were allowed to spread into a continuous cover. The sods were mowed one or more times during the growing season to reduce top growth; sometimes they were raked to furnish mulch for the trees.

The amount of top growth produced by the different sods before and after mowing suggested that they may also vary in the amount of water that they withdraw from the soil. Since rainfall is the only source of soil moisture available for sod and tree growth in most Michigan orchards, the shallow-rooted, less vigorously growing and less water-consuming sods seemed best to plant. Such sods should compete less with the trees for moisture, leaving more of it available for tree growth and production of fruit.

Only limited field data are available on the amount and depth of water removal by the various sods found in Michigan orchards. Inquiries from growers regarding the best sods to conserve soil moisture

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could only be answered in a suggestive way. Furthermore, it was not clearly determined whether mowing the sods in mid-June would save soil moisture.

Therefore, an experiment to determine the relative amount and depth of soil moisture depletion by the more common orchard sods was started at the Michigan State University Graham Experiment Station in 1950 and continued through the 1954 season. Soil moisture losses from mowed and unmowed plots of each sod were also compared.

PROCEDURE

An area of about 1.1 acres of Miami silt loam soil was divided into 53 plots, each 27 feet square. Replicate plots of each sod cover were randomized in the area. These included seven plots each of Kentucky bluegrass, timothy, Chewing's fescue, redtop, and quackgrass; four each of white dutch clover and Ladino clover; and three of alfalfa. In addition, three plots were kept clean cultivated, and four were mulched with grass hay.

Sods were established in their respective plots in early September of 1950; quackgrass was established by means of roots or stolons. Alfalfa plots were seeded in early August 1951.

Each plot was divided into four subplots of equal size, 13½ by 13½ feet. In the spring of 1951, five gypsum soil moisture absorption blocks, (Bouyoucos) were installed in a vertical hole in the center of each subplot, at 8, 16, 24, 32, and 40-inch depths. The wire leads from each installation were brought underground to the center of each plot to facilitate moisture determination readings. Weekly moisture determinations were made during the growing season by a portable meter which indicated the percentage of available moisture in the soil surrounding each individual gypsum block.

Half of each sod plot was mowed once annually, about mid-June, to determine the influence of mowing on the amount of water used by the different sods. The clippings were removed from the mowed portions of the plots to avoid smothering of the sods. The remaining half of the sod plots was not mowed. The clean cultivated plots were cultivated as needed to control weeds. The mulch plots received 280 pounds of hay (about 3 tons per acre) in the summer of 1951.

The field capacity of the Miami silt loam used in this study was about 15 percent of the dry weight of the soil. About one-third (5 percent) of this moisture was unavailable to the plants (below wilting point), while the remaining two-thirds (10 percent) was in the avail-

able range. Thus, the available soil moisture would amount to about 1 gallon of water per cubic foot of soil.

RESULTS

Intensity of moisture depletion by the different sods coincided closely with distribution and amount of rainfall during each of the four growing seasons. Therefore, each year is considered separately. The driest dates during each year were selected to indicate the comparative moisture-depleting capacity of each sod cover.

1951 Season

The different sods had not reached full maturity during the early part of their first growing season. However, by midsummer, depth of rooting was indicated through the depletion of soil moisture. On the driest date (about August 9), bluegrass had removed soil moisture to a depth of 24 inches; the white dutch clover had withdrawn moisture to 32 inches. Timothy and fescue had used some soil moisture from the 32-inch depth; while the redtop, quackgrass, and Ladino clover had reduced it slightly at the 40-inch level.

Table 1 shows the average percent of available soil moisture remaining at the different soil depths on August 9, 1951 for the mowed and unmowed sods. Except for Ladino clover plot, there was more

TABLE 1—Average percent of available soil moisture at different depths under mowed and unmowed plots of seven sod covers and under cultivated and mulch plots on August 9, 1951 (driest date of season)

Plots	8 in.	16 in.	24 in.	32 in.	40 in.	Average of all depths	
						Mowed*	Not mowed
Kentucky bluegrass..	9.4	15.3	42.9	100.0	100.0	53.5	55.6
Timothy.....	9.4	10.8	31.6	96.3	100.0	49.6	50.8
Chewing's fescue.....	9.2	10.8	32.3	88.3	100.0	48.1	50.1
Redtop.....	9.3	9.9	13.6	46.3	96.0	35.0	42.0
Quackgrass.....	10.4	12.5	19.3	56.4	92.0	38.1	41.0
White dutch clover...	9.5	9.7	12.0	39.0	100.0	34.0	42.0
Ladino clover.....	10.0	11.2	14.5	44.0	91.0	34.1	32.3
Cultivated.....	98.4	100.0	100.0	100.0	100.0	99.7	
Mulched.....	100.0	100.0	100.0	100.0	100.0	100.0	

*Plots mowed on June 8.

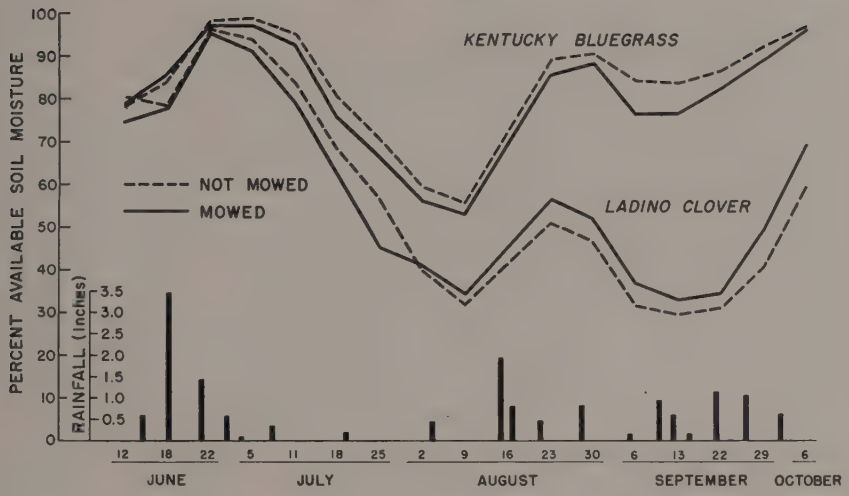

Fig. 1. Average percent of available soil moisture to a depth of 40 inches under mowed and unmowed sods of Kentucky bluegrass and Ladino clover during the summer and fall of 1951.

moisture under all unmowed sods from late June to October 6. Mowed Ladino clover depleted soil moisture more than when unmowed until August 1. The opposite was found later in the season. Available moisture remained at essentially field capacity in both the cultivated and mulch plots.

The two sods shown in Fig. 1 are typical of the light and heavy users of soil moisture during the experiment. Timothy, fescue, and redtop were similar to bluegrass in moisture utilization. White dutch clover and alfalfa were similar to Ladino clover. Water usage by quackgrass was intermediate between bluegrass and Ladino clover.

Well-distributed rainfall from August 9 to October 6 markedly increased the percent of available soil moisture in the sod plots. The greatest increase occurred in the bluegrass plots; the least took place in the Ladino clover plots. The amount of moisture depletion during this same period was greater for Ladino clover. Mowed and unmowed bluegrass reduced available moisture 11 and 6 percent, respectively, for 7 to 10 days beginning about August 30. Starting 1 week earlier, mowed and unmowed Ladino clover depleted it 23 and 21 percent, respectively, over a period of 3 weeks.

1952 Season

During the second year, all sods (except alfalfa) had reached maturity and showed their relative effects on moisture depletion by mid-July. Table 2 shows the comparative amount and depth of moisture use by the mowed sods on July 14 which was the driest date in midsummer (about 4 weeks earlier than in 1951). Bluegrass, timothy, fescue, and redtop depleted soil moisture mostly in the upper 24 inches of soil.

Quackgrass, Ladino clover, and white dutch clover depleted moisture markedly at the 40-inch depth. Comparing the extremes in water usage by the two representative sods on July 14, the available moisture under Ladino clover was reduced to 42 percent at the 40-inch depth, the same as that found under bluegrass at the shallower depth of 24 inches. Similarly, alfalfa seriously depleted moisture to a depth of 32 inches by July 14, and it reached a depth of 40 inches by September 1.

Mowing increased moisture depletion 2 and 3 percent, respectively, under Ladino clover and alfalfa; it conserved it 3.4 to 19.4 percent under the remaining sods as of July 14. Soil moisture remained at field capacity under the mulch, but it was depleted 30 percent at 8 inches and 20 percent at 16 inches in the cultivated area.

Substantial summer rainfall, starting on July 8, increased and maintained the available soil moisture at a comparatively high and constant

TABLE 2—Average percent of available soil moisture at different depths under mowed and unmowed plots of eight sod covers and under cultivated and mulch plots on July 14, 1951 (driest date in summer)

Plots	8 in.	16 in.	24 in.	32 in.	40 in.	Average of all depths	
						Mowed*	Not mowed
Kentucky bluegrass	11.1	14.9	42.4	98.8	100.0	53.4	50.0
Timothy	20.0	26.4	50.1	92.9	96.9	57.3	42.3
Chewing's fescue	10.8	11.8	28.2	89.4	100.0	48.0	43.7
Redtop	13.9	18.1	37.1	87.4	100.0	51.3	31.9
Quackgrass	11.9	12.5	15.9	28.1	65.1	26.7	16.4
White dutch clover	10.8	10.8	11.3	16.2	59.2	21.7	16.1
Ladino clover	11.5	12.2	13.0	15.7	42.0	18.9	21.1
Alfalfa	12.2	12.2	13.7	21.3	80.0†	27.9	31.3
Cultivated	70.0	79.4	95.8	100.0	100.0	89.0	
Mulched	97.5	97.8	100.0	100.0	100.0	99.1	

*Plots mowed on June 16.
†Alfalfa roots apparently are just beginning to penetrate this depth (11 months after seeding).

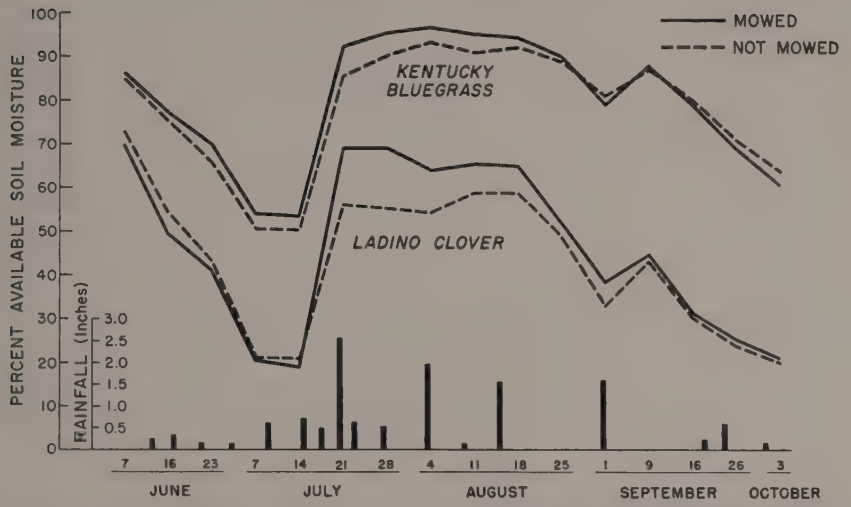

Fig. 2. Average percent of available soil moisture to a depth of 40 inches under mowed and unmowed sods of Kentucky bluegrass and Ladino clover during the summer and fall of 1952.

level from about July 20 to August 20. As shown in Fig. 2, there was considerably more moisture under bluegrass sod than under Ladino clover.

Starting about August 20, moisture declined steadily under both sods (except for a short period between September 1 to 9) until the last determinations were made on October 3. During this period, the average percent of available moisture to a depth of 40 inches was not depleted below 61 percent under the mowed and unmowed plots of bluegrass. Under Ladino clover, it was reduced to about 21 percent by October 3.

Total average available moisture in the upper 40 inches of soil was somewhat higher under all sods except alfalfa on October 3 than on July 14 (Table 3). The increase of moisture was confined primarily to a depth of 24 inches. Alfalfa continued to deplete soil moisture at the 32 and 40-inch depths throughout the period. By October 3, alfalfa (mowed and unmowed) had reduced available moisture to a depth of 40 inches an additional 11.2 and 13.7 percent, respectively, below that found on July 14.

The earlier conservation of moisture by mowing did not continue through to October 3 for all sods. On this date, mowed sods of timothy, redtop, quackgrass, and dutch clover had reduced available mois-

TABLE 3—Average percent of available soil moisture at different depths under mowed and unmowed plots of eight sod covers and under cultivated and mulched plots on October 3, 1952 (driest date in the fall)

Plots	8 in.	16 in.	24 in.	32 in.	40 in.	Average of all depths	
						Mowed*	Not mowed
Kentucky bluegrass..	16.5	30.6	71.0	92.4	97.1	63.0	61.0
Timothy.....	21.3	36.8	69.8	89.9	89.3	61.4	81.9
Chewing's fescue.....	13.7	22.9	55.9	89.3	99.1	56.2	48.7
Redtop.....	13.3	22.4	50.8	87.8	99.6	54.8	59.6
Quackgrass.....	17.4	19.9	31.1	48.7	68.1	37.0	42.9
White dutch clover...	11.8	12.8	15.2	24.8	57.8	24.5	28.5
Ladino clover.....	12.8	14.3	17.0	19.8	44.0	21.6	21.1
Alfalfa.....	16.3	16.3	15.5	15.7	19.7	16.7	17.6
Cultivated.....	44.6	69.3	87.8	100.0	100.0	80.3	
Mulched.....	84.0	88.5	98.5	99.3	98.5	93.8	

*Plots mowed on June 16.

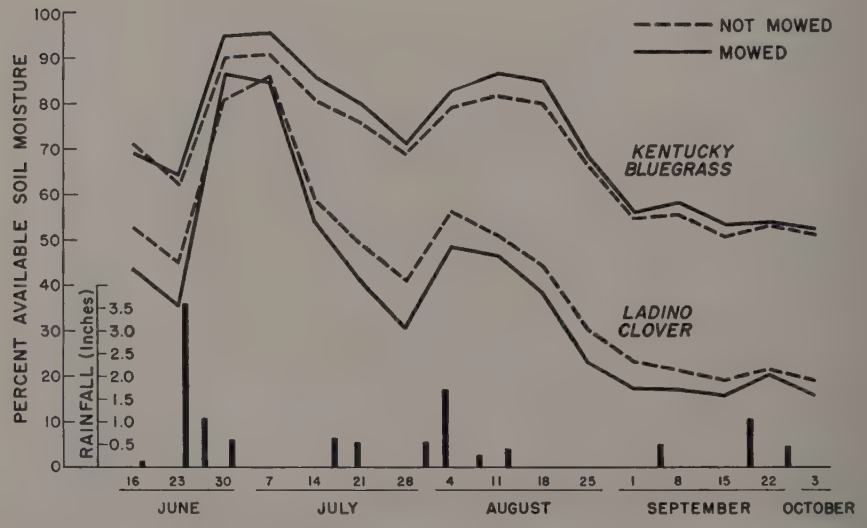

Fig. 3. Average percent of available soil moisture to a depth of 40 inches under mowed and unmowed sods of Kentucky bluegrass and Ladino clover during the summer and fall of 1953.

ture 20.5, 4.8, 5.9, and 4.0 percent, respectively, below that found under those covers not mowed. Mowing of bluegrass and fescue conserved 2.0 and 7.5 percent moisture, respectively, when compared to those unmowed treatments. In both the cultivated and mulched plots, there was a continuous loss of soil moisture in the upper levels, with the greater loss occurring in the cultivated plots.

1953 Season

Light rainfall and active growth of the sods caused a steady decline in available soil moisture during the early growing season in 1953. Replenishing rains, starting on June 24, halted this downward trend temporarily; by July 1, soil moisture in all plots had increased to a comparatively high level (Fig. 3). On July 7, a second decline started and continued until about August 1.

The comparative amount and depth of moisture depletion by the eight sod covers on July 28, the driest period in midsummer, is shown in Table 4. At this time, bluegrass, timothy, fescue, and redtop had depleted available soil moisture less than 15 percent at the 24-inch level. Quackgrass reduced it 35 percent at this depth; while dutch and Ladino clovers had depleted it about 48 and 73 percent, respectively, at the 32-inch depth.

Alfalfa depleted moisture at all depths, reducing it to 48.6 percent at 40 inches. This was 13.9 percent lower than that found under timothy at the 8-inch depth, and 6.3 percent lower than found under blue-

TABLE 4—Average percent of available soil moisture at different depths under mowed and unmowed plots of eight sod covers on July 28, 1953 (driest date in midsummer)

Plots	8 in.	16 in.	24 in.	32 in.	40 in.	Average of all depths	
						Mowed*	Not mowed
Kentucky bluegrass	23.0	54.9	89.3	92.8	97.9	71.6	68.3
Timothy	62.5	72.7	90.7	93.4	92.2	82.3	63.6
Chewing's fescue	21.6	46.9	86.0	95.0	95.0	68.9	58.9
Redtop	16.6	35.1	85.9	95.1	98.6	66.3	61.3
Quackgrass	33.6	41.2	64.4	90.1	97.5	65.4	58.8
White dutch clover	14.2	16.2	24.3	52.3	87.2	38.8	42.1
Ladino clover	11.3	13.0	16.0	27.3	85.3	30.6	41.5
Alfalfa	36.2	46.6	41.8	42.2	48.6	43.1	43.9

*Plots mowed on June 20.

grass at the 16-inch depth. Mowing had conserved as much as 19 percent of the available soil moisture under the grass sods, but it had not conserved moisture under the legume sods.

The degree of moisture depletion by the two representative sods (Kentucky bluegrass and Ladino clover) varied considerably during July (Fig. 3). Between July 7 and July 28, the mowed sods of bluegrass and Ladino clover reduced the available soil moisture an average of 24 and 54 percent, respectively, to a depth of 40 inches. During this same period, the unmowed sods reduced it an average of 22 and 44 percent, respectively.

Total rainfall of 2.3 inches from August 1 to 4 improved soil moisture in the sod plots. However, Ladino clover began to deplete soil moisture almost immediately, while bluegrass started reducing soil moisture a week later (Fig. 3). By October 3, less than 20 percent of the available moisture remained in the first 40 inches of soil under the Ladino clover sod. In comparative plots of bluegrass, the available moisture was not depleted below 50 percent.

Table 5 shows the average percent of available moisture remaining on October 3 at the different depths under the eight sod covers. Bluegrass and timothy had depleted available moisture less than 14 percent at the 32-inch depth, while fescue and redtop had used about 27 percent. Quackgrass reduced available moisture 47 percent at the 40-inch depth. The two clover sods had depleted moisture about 70 percent; depletion from alfalfa was 79 percent to the 40-inch depth.

TABLE 5—Average percent of available soil moisture at different depths under mowed and unmowed plots of eight sod covers on October 3, 1953 (driest date in fall)

Plots	8 in.	16 in.	24 in.	32 in.	40 in.	Average of all depths	
						Mowed*	Not mowed
Kentucky bluegrass..	16.0	21.0	42.2	91.3	95.9	53.3	51.0
Timothy.....	19.4	23.3	43.9	86.2	92.4	53.0	53.6
Chewing's fescue.....	14.2	15.3	25.7	73.1	94.7	44.6	40.1
Redtop.....	15.8	17.4	26.8	72.5	93.2	45.1	43.8
Quackgrass.....	21.2	21.0	25.1	30.4	53.2	30.2	37.4
White dutch clover...	12.6	12.8	14.6	14.5	29.6	16.8	17.5
Ladino clover.....	12.3	12.0	12.3	14.0	28.3	15.8	18.8
Alfalfa.....	18.6	19.0	18.6	16.0	20.8	18.6	17.7

*Plots mowed on June 20.

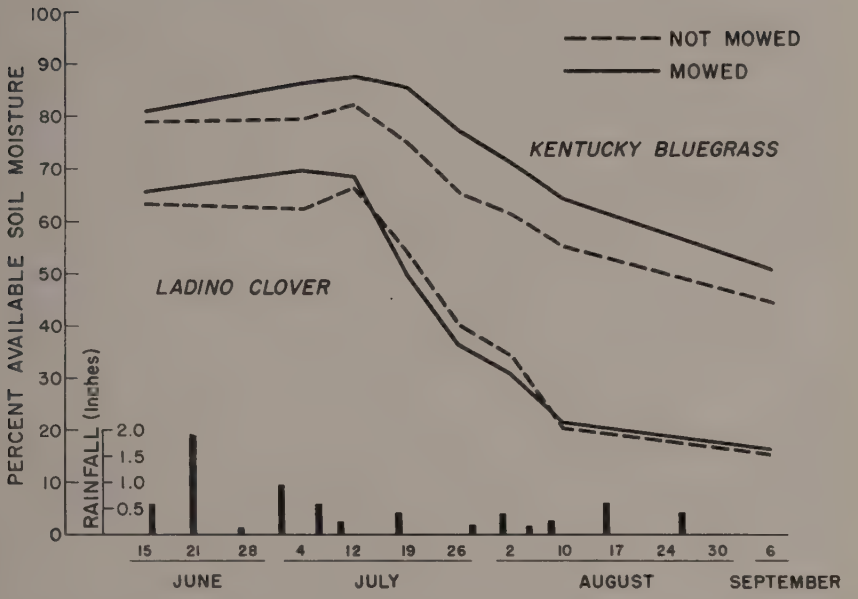

Fig. 4. Average percent of available soil moisture to a depth of 40 inches under mowed and unmowed sods of Kentucky bluegrass and Ladino clover during the summer of 1954.

As indicated, mowing did conserve a small amount of moisture under bluegrass, fescue, redtop, and alfalfa. However, mowing of timothy did not conserve moisture, while mowing quackgrass and the two clover sods resulted in a somewhat greater depletion.

1954 Season

During this 4-year study, the 1954 season provided the most favorable conditions for evaluating the comparative moisture requirements of the various sods. Lack of summer rainfall and continued use of water by the sods caused soil moisture to decline steadily from mid-July to early September (Fig. 4).

The average percentages of available moisture remaining at the different depths under the mowed sods on September 6 are shown in Table 6. September 6 was the last determination and driest date recorded during the season. At the 24-inch depth, 45.2, 42.2, 27.4 and 28.0 percent of available soil moisture remained under the bluegrass, timothy, fescue, and redtop sods, respectively.

At the 32-inch depth, these four sods did not deplete moisture below 71.8 percent. Quackgrass depleted it to 31.0, 45.6 and 63.4 percent at the 24, 32, and 40-inch depths, respectively. The three legume sods reduced the available moisture seriously at all depths. The percent of available soil moisture (23.2 to 28.3) remaining at the 40-inch depth for the legumes was only slightly more than that found under the bluegrass and timothy sods at the 16-inch depth; it was about equal to that under fescue and redtop at 24 inches.

Average percentages of moisture for all depths under the mowed and unmowed sods show that the mowed grass sods used from 4.3 to 10.9 percent less soil moisture than the unmowed. However, mowing Ladino clover, dutch clover, and alfalfa had essentially no effect on moisture depletion.

Fig. 4 presents the comparable rapidity and intensity of moisture depletion of the mowed and unmowed representative sods. From July 12 to August 10, mowed bluegrass and Ladino clover depleted moisture 23 and 46 percent, respectively, to the depth of 40 inches as compared to 27 and 47 percent for the unmowed sods. Soil moisture was still declining under both these sod treatments when the last moisture readings were taken on September 6. On this date, the average percent of available soil moisture remaining under mowed bluegrass was 35.2 percent more than that under Ladino clover.

TABLE 6—Average percent of available soil moisture at different depths under mowed and unmowed plots of eight sod covers on September 6, 1954 (last determination and driest date in 1954)

Plots	8 in.	16 in.	24 in.	32 in.	40 in.	Average of all depths	
						Mowed*	Not mowed
Kentucky bluegrass.	16.0	21.9	45.2	83.2	89.1	51.1	44.4
Timothy.....	18.8	25.7	42.2	71.8	84.0	44.5	40.2
Chewing's fescue.....	13.8	15.0	27.4	76.9	90.3	44.7	33.8
Redtop.....	14.6	16.3	28.0	78.8	89.4	45.4	35.3
Quackgrass.....	21.4	20.4	31.0	45.6	63.4	36.4	27.7
White dutch clover...	14.3	15.0	13.3	14.7	27.0	16.9	18.1
Ladino clover.....	12.0	12.7	13.0	13.7	28.3	15.9	15.0
Alfalfa.....	18.4	19.0	19.6	15.2	23.2	19.1	17.2

*Plots mowed on June 16.

TABLE 7—Average percent of available soil moisture at different depths under mowed and unmowed plots of eight sod covers: average of the two driest dates in 1952, two in 1953, and one in 1954

Plots	8 in.	16 in.	24 in.	32 in.	40 in.	Average of all depths	
						Mowed	Not mowed
Kentucky bluegrass..	16.5	28.7	58.0	91.7	96.0	58.2	59.9
Timothy.....	28.4	37.0	59.3	86.8	91.0	60.5	56.3
Chewing's fescue.....	14.8	22.4	44.6	84.7	95.8	52.5	45.0
Redtop.....	14.8	21.9	45.7	84.3	96.2	52.6	46.4
Average.....	18.6	27.5	51.9	86.9	94.7	55.9	51.9
Quackgrass.....	21.1	23.0	33.5	48.6	69.5	39.1	36.6
White dutch clover...	12.7	13.5	15.7	24.5	52.2	23.7	24.5
Ladino clover.....	12.0	12.8	14.3	18.1	45.6	20.6	23.5
Alfalfa.....	20.3	22.6	21.8	22.1	28.1	23.0	25.5
Average.....	15.0	16.3	17.3	21.6	41.6	22.4	24.5

Seasons Compared

Table 7 shows the average soil moisture for the mowed sods on the two driest dates in 1952 and 1953; one is given for 1954. Data showing the effect of mowing are also given. Data for 1951 were not included, since the various covers had not become established as a sod, having been seeded in 1950.

As indicated by Table 7, bluegrass, timothy, fescue, and redtop form a group which used the least amount of moisture. These sods also used moisture from shallower depths. An average of 51.9 percent of available moisture remained under these sods at the 24-inch depth. This was three times more than remained under the legume sods at the same depth; it was about one-fourth more than that under legumes at the 40-inch level. The average percent of available moisture to a depth of 40 inches under the mowed grass and legume sods was 55.9 and 22.4 percent, respectively. The average for quackgrass was about midway between the legumes and the other four grass sods.

Table 8 shows the influence of mowing on the conservation or depletion of soil moisture during the 4-year study. Each year was divided into two periods, early and late summer. Early summer included the period from mowing to early August, and late summer

covered the remainder of the year. This seasonal division was made to determine if the influence of mowing was of shorter or longer duration for each of the sods under study.

Dates or periods of lowest moisture content of the soil during midsummer were not considered in this seasonal division. The percentages of available moisture shown in Table 8 indicate the amount that was conserved (+) or depleted (—) as the result of mowing in comparison to the unmowed sods during the two specified periods.

The first year after seeding (1951), the mowed sods depleted soil moisture about equal to or slightly more than the unmowed during early summer. During late summer, moisture depletion increased under all mowed sods except Ladino clover. The greatest depletion in late summer occurred under mowed redtop which used 28.8 percent more moisture than the unmowed plot.

In 1952, mowing conserved soil moisture under all sods from 2.2 to 13.3 percent during early summer; during late summer, it ranged from 2.4 to 6.5 percent under fescue, Ladino clover, and alfalfa. Mowing did not save moisture in late summer under the remaining five sods. The amount of depletion ranged from 0.5 to 8.5 percent below that found under the unmowed sods.

In the early summer of 1953, mowed Ladino and dutch clovers withdrew slightly more moisture than did the unmowed. During this same period, the remaining sods used less moisture when mowed than

TABLE 8—Influence of mowing on soil moisture conservation or depletion to a depth of 40 inches, by eight sod covers during early and late summer periods in 1951, 1952, 1953, and 1954 (percent on basis of mowed sods)

Plots	1951		1952		1953		1954		1952, 1953, 1954 annual average	
	Early summer*	Late summer†	Early summer*	Late summer†	Early summer*	Late summer†	Early summer*	Late summer†	Early summer*	Late summer†
Kentucky bluegrass	−1.7	− 4.2	+ 4.2	−0.5	+4.0	+2.6	+ 8.8	+ 8.5	+ 5.7	+3.5
Timothy	−0.3	− 8.3	+ 7.7	−8.5	+9.0	−1.3	+29.2	+16.5	+15.3	+2.2
Chewing's fescue	−0.4	− 3.6	+ 5.5	+6.5	+8.4	+5.9	+15.0	+14.5	+ 9.6	+9.0
Redtop	−5.5	−28.8	+11.7	−4.2	+3.0	+0.4	+18.8	+10.5	+11.2	+2.0
Quackgrass	+0.2	− 6.1	+13.3	−1.9	+8.9	−5.6	+19.2	+11.0	+13.8	+1.2
White dutch clover	−4.1	−12.8	+ 3.6	−5.1	−2.4	−2.1	− 4.2	− 3.5	− 1.0	−3.6
Ladino clover	−3.0	+ 5.9	+ 4.2	+ 2.8	−5.1	−4.7	− 0.2	+ 1.0	− 0.4	−0.3
Alfalfa	...	...	+ 2.2	+2.4	+1.0	−2.6	+ 6.4	+ 3.5	+ 3.2	+1.1
Rainfall inches	7.41	8.57	8.34	4.16	9.15	2.34	5.58	1.23	...	...

* From the time of mowing to early August.
† After early August.
\+ Percent of moisture conserved as the result of mowing.
− Percent of moisture depletion as the result of mowing.

when unmowed. During late summer, mowing continued to conserve moisture under bluegrass, fescue and, to a very slight extent, under redtop; but it increased water usage by the remainder of the sods.

With less rainfall in 1954, mowing saved much more soil moisture during both periods under alfalfa and the grass sods than it did in 1952 and 1953. The greater percentage of moisture was conserved in early summer. During early and late summer, mowed dutch clover depleted moisture 4.2 and 3.5 percent more, respectively, than did the unmowed. Mowed Ladino clover used about equal amounts of moisture as did the unmowed in early summer and in late summer.

The influence of mowing varied between the individual sods during early and late summer in the 1952, 1953 and 1954 seasons. During these 3 years, mowing in mid-June conserved soil moisture under alfalfa and the five grass sods in early summer, although the average amount was small in some instances.

During late summer, mowing continued to conserve moisture under fescue; in 2 of the 3 years, moisture was saved under bluegrass, redtop, Ladino clover, and alfalfa. Mowing did not conserve moisture in late summer under timothy and quackgrass in 2 of the 3 years. Except during early summer in 1952, mowed white dutch clover depleted moisture from 2.1 to 5.1 percent more than the unmowed in both periods.

Based on the annual average for the 3 years, mowing saved substantial amounts of moisture under the grass sods in early summer but only small amounts during late summer. Mowing the legumes did not greatly affect moisture conservation or depletion during the 3-year period.

DISCUSSION

Adequate soil moisture is essential for the maximum yields of high quality fruit. With irrigation, water can be applied when needed. In areas like Michigan, however, where rainfall does not greatly exceed the requirements of fruit trees, cultural practices should be employed to reduce runoff losses and to conserve water.

Research and experience have demonstrated that sod covers reduce runoff losses and increase water infiltration. Shaulis and Merkle (1939) have shown that conditions favoring water conservation such as porosity, structure, and organic matter content of the soil can be obtained and/or maintained in orchards by growing sods. Collison (1935) con-

cluded that soil structure was improved by growing sods to permit greater absorption and retention of rainfall.

Toenjes (1955) found substantially higher soil moisture levels, at a depth of 42 inches, under sod than under clean cultivated areas in a mature Bartlett pear orchard. Ellenwood and Gourley (1935) showed that moisture levels in soils growing Kentucky bluegrass, timothy, redtop, and orchard grass compared favorably with the moisture levels found in clean cultivated soils. Collison (1940) likewise found similar moisture conditions under Kentucky bluegrass sod and clean cultivated soils.

The comparable amount and depth of soil moisture depletion varies between grass and alfalfa sods. Howlett (1936) found that alfalfa sod induced considerably more soil moisture deficiency and retarded the growth of young pear trees more than did a bluegrass sod. Baker (1953) pointed out that alfalfa competes more seriously with the trees for soil moisture than do the shallow-rooted grasses. Harrison and Partridge (1943) earlier advised against seeding alfalfa in Michigan orchards.

These and other findings substantiate the data obtained in this experiment. The data presented showed that grass sods used less moisture than legume sods. Also, the grass sods drew moisture from a shallower depth than did the legumes. Thus, the moisture not used by grass sods would be available to trees whose roots extend beyond the depth of moisture depletion (Fig. 5).

The depth of moisture depletion by legume sods could materially reduce fruit size and tree growth during seasons of deficient rainfall; this factor could also increase the effects of continued drought.

Aside from greater moisture depletion, the presence of legume sods may also be accompanied by other difficulties in the orchard. Buffalo tree hoppers often injure young trees severely where grown in combination with legume sods. In extreme cases, trees have been killed by these insects or damaged so badly that they had to be replaced.

Furthermore, apple growers who maintain alfalfa sod in their orchard have complained of poor fruit color at harvest. This may be due to increased soil nitrogen brought about by legumes, or to the placing of the high-nitrogen alfalfa clippings beneath the trees in early summer, or both. However, according to the data presented, the possibility of moisture depletion cannot be overlooked.

The grass sods used in this study grow more luxuriantly during the cooler temperatures in May and June and again after late August. By mid-July or early August, their top growth normally lessens; it

Fig. 5. Partially exposed apple tree root system showing the depth of root penetration. The lowest exposed root was about 6 feet below the soil surface and still continuing downward. This depth is well below that occupied by the grass sod roots. Surface soil is sandy loam about 15 inches deep; the subsoil is rather dense brown clay.

hardens off shortly after seed ripening and turns brown, and the plants become nearly dormant during the hot summer period. Both the mowed and unmowed grasses use less moisture during this comparatively inactive growth period.

Mowing the still actively growing grass sods in mid-June temporarily reduced their water usage and conserved soil moisture. The amount and the length of time that moisture is conserved by mowing depends upon the available moisture content of the soil. Abundant soil moisture encourages regrowth of the grass sods after mowing; by early August,

these grasses may use as much moisture as those unmowed. However, if available moisture is not abundant at the time of mowing or shortly after, or if it is short during late summer (as in 1954), less regrowth takes place.

The period of restricted top growth and reduced water usage can, therefore, extend from the time of mowing until early September during a dry season (Fig. 6). Since mowing in mid-June tends to save moisture under grass sods during early summer, repeated mowings may likewise continue to conserve it during late summer and early fall.

Had the grass sods been competing with orchard trees for moisture, their periods of active growth may have been much shorter than those in the open field plots. Simultanous depletion of soil moisture by the trees and sod would have reduced available moisture to an unfavorable growth level for the sods earlier and for a longer time during the season. Under such conditions, the sods would have drawn less water from the soil than they did in this experiment.

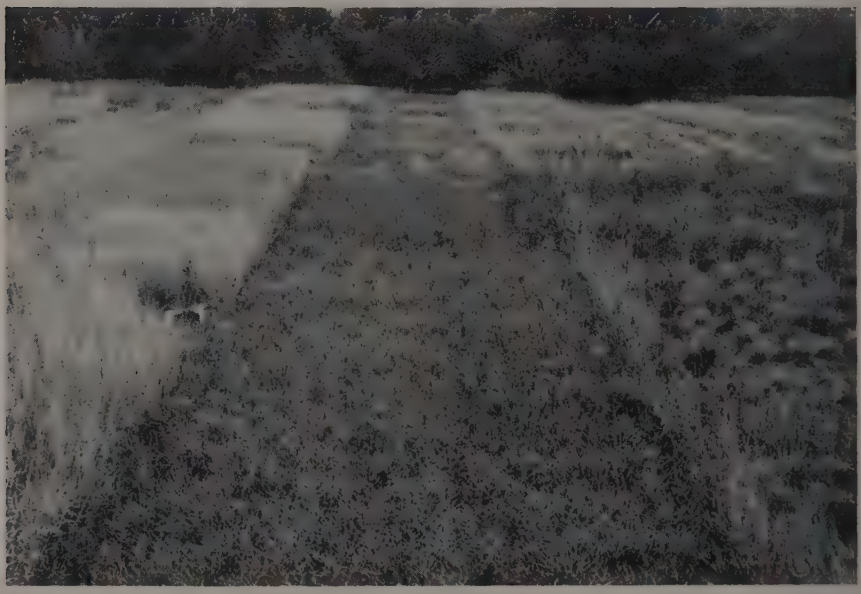

Fig. 6. The amount of regrowth of the mowed sods during the dry summer of 1954, after mowing on June 16 (photographed September 11, 1954). Unmowed portions of the plots are left of center. Center section shows mowed portion of plots. Sod plots from front to rear are redtop, timothy, Kentucky bluegrass, redtop, white dutch clover and timothy. (Photo by K. K. Vining)

Except under severe drouth conditions, alfalfa, Ladino, and white dutch clovers start regrowth almost immediately after mowing. They are unlike the grass sods in this respect. Reserve water usually found between the 24- and 40-inch levels under grass sods is practically nonexistent under the legume sods. The ability of legumes to continue growth during the hot summer months and to obtain water from the lower soil depths depletes moisture seriously in the lower tree root zone. As a result, tree growth and fruit development can and do suffer for lack of moisture during seasons of deficient rainfall.

SUMMARY AND CONCLUSIONS

As Michigan's average annual rainfall does not exceed fruit tree needs, its conservation is very important. The best way to do this is to use soil cultural practices that save moisture.

Among the most successful of these is permanent sod cover. It conserves rainfall by reducing surface runoff and by increasing water infiltration.

Soils with considerable amount of clay in surface and/or subsoil horizons can absorb and store enough water for both the normal needs of the trees and sod covers having low moisture requirements.

Permanent sod covers used most often in Michigan orchards vary considerably in the depth to which they deplete soil moisture. Kentucky bluegrass, timothy, redtop, and Chewing's fescue grass sods depleted soil moisture the least; they satisfied their needs primarily from the upper 24 inches of soil. These four grasses were similar in both amount and depth of depletion.

The legume sods, white dutch clover, Ladino clover, and alfalfa, depleted soil moisture seriously to the lowest measured depth of 40 inches. White dutch clover used somewhat less moisture than Ladino and alfalfa. Ladino clover and alfalfa used moisture about equally to a depth of 40-inches. Quackgrass water usage was intermediate between the grasses and legumes.

Mowing about mid-June conserved soil moisture under the grass sods and the alfalfa sod during early summer of 1952, 1953, and 1954. The moisture-conserving influence of mowing extended into late summer under some grasses and alfalfa in years of low midsummer rainfall.

Abundant soil moisture at the time of mowing or shortly after encouraged more rapid regrowth of the mowed sods, increasing deple-

tion of soil moisture in late summer. During such seasons, repeated mowings of the new growth should continue to reduce water usage.

One mowing in mid-June conserved more moisture during seasons of deficient summer rainfall; regrowth of the mowed sods remained low because of drouthy conditions.

Michigan fruit growers about to establish permanent sod cover in their orchards should consider sods that have a shallow root system and which are less competitive with the trees for moisture.

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A THEORETICAL RELATIONSHIP OF THE VARIABLES AFFECTING THE OPERATION OF CONTROLLED ATMOSPHERE STORAGE ROOMS

By I. J. PFLUG and D. H. DEWEY
DEPARTMENT OF AGRICULTURAL ENGINEERING AND HORTICULTURE

THE SUCCESSFUL CONTROL of the carbon dioxide and oxygen composition of a controlled atmosphere (CA) apple storage is primarily determined by the utilization and production of these gases by the stored fruit and by the passage of the gases in and out of the storage room.

As living plant tissues, fresh fruit respires, a process in which the carbohydrates of the fruit are chemically combined with oxygen from the atmosphere to form water and carbon dioxide. The carbon dioxide produced and released as a gas to the atmosphere is normally equivalent in volume to that of the oxygen used. The temperature coefficient (Q_{10}) of the respiration process for apples ranges from 2 to 3. Cooling the fruit, therefore, reduces the rate of respiration ½ to ⅔ for each temperature reduction of 18° F. (10° C.) in the range of 90° to 32° F.

The respiratory activity of apples is also slowed by modification of the atmosphere as the supply of oxygen becomes limited and carbon dioxide accumulates within the storage room. The latter factors are dependent upon the gas exchange characteristics of the building as well as upon the consumption and production of the gases by the fruit.

Smock[1] recommended that the CA room should be 92 to 95 percent gastight so that the leakage rate would be no greater than 0.05 to 0.08 air changes per 24 hours. He further stressed the need for a completely filled room as an aid in reaching the desired atmospheric modification. Pflug and Dewey[2] have shown the theoretical effects of

[1]Smock, R. M. (1949). Controlled atmosphere storage of apples. Cornell Univ. Ext. Bul. 759. 39 pp.
[2]Pflug, I. J., and D. H. Dewey (1953). Controlled atmosphere storage. Ag. Eng. 36: 171-172.

ARTICLE 39-35

different degrees of room fullness on the time required for a CA storage to develop the desired concentrations of oxygen and carbon dioxide.

The inter-relationship of fruit respiration, quantity of fruit stored, and gas exchange characteristics of the storage room is difficult to visualize in the operation of a CA storage room, and in the modification of atmospheres surrounding fresh produce stored in sealed film packages and liners.

The operation of a particular CA storage is influenced by many variables. The variables considered with their symbols and units are listed below:

	Symbol	Units
Storage room volume (gross)	V	$ft.^3$
Quantity of fruit in storage	B	bushels
Space factor	$Z = \frac{V}{B}$	$\frac{ft.^3}{bu}$
Respiration rate	r	$\frac{ft.^3 O_2 \text{ consumed}}{bu.\ day}$
Equilibrium oxygen level in storage	y	$\frac{ft.^3 O_2}{ft.^3 \text{ atmosphere}}$
Controlled carbon dioxide level in storage	c	$\frac{ft.^3 CO_2}{ft.^3 \text{ atmosphere}}$
Leakage or ventilation rate	x	$\frac{\text{air changes}}{24 \text{ hours}}$
Temperature	t	° F.
Oxygen in standard atmosphere		$\frac{0.21\ ft.^3}{ft.^3 \text{ atmosphere}}$
Bushel of apples		45 lb.

The operation of CA rooms falls into two distinct types: (1) the sum of the oxygen level plus carbon dioxide level is 0.21; and (2) the sum of oxygen plus carbon dioxide is less than 0.21. In Type 1, the gas level is controlled by ventilation only; whereas, in Type 2, carbon dioxide is removed by chemical absorption and the oxygen is controlled by ventilation. In the latter type, the oxygen level of the storage atmosphere can be as low as 0.03 with the carbon dioxide level maintained at 0.05.

Equilibrium oxygen level of storage maintained by ventilation only, (Type 1).

In a storage room where the oxygen level is determined by the relative amounts of oxygen consumption and ventilation, the equilibrium oxygen level is determined by the oxygen consumption of the fruit,

$$\text{Oxygen consumed } \frac{(\text{ft.}^3)}{(\text{day})} = \text{Br},$$

and the oxygen gain of the storage,

$$\text{Oxygen gain } \frac{(\text{ft.}^3)}{(\text{day})} = \text{Vx } (0.21 - \text{y}).$$

Since the oxygen gain of the storage must equal oxygen consumed, at the equilibrium oxygen level,

$$\text{Br} = \text{Vx } (0.21 - \text{y}), \text{ and } \text{y} = 0.21 - \frac{\text{r}}{\text{xz}} \text{ (Equation 1)}$$

Equation 1 is illustrated graphically in Fig. 1, using a respiration rate of 0.015 and a room space factor of 2.5.

Equilibrium oxygen level of storage maintained by absorbing carbond dioxide and ventilating to add oxygen (Type 2).

When carbon dioxide is removed by absorption from the CA storage, a volume of air, equal to the volume of carbon dioxide removed, will be drawn into the storage room in addition to air changes due to leakage. Since carbon dioxide is usually absorbed at a high rate for a short period of time, the air entering the storage due to absorption of carbon dioxide must be treated separately from leakage due to other causes. The amount of oxygen added to the storage as a result of carbon dioxide removal is,

$$\text{Oxygen added } \frac{(\text{ft.}^3)}{(\text{day})} = (\text{rB} - \text{Vxc}) \, 0.21.$$

The oxygen added by leakage is,

$$\text{Oxygen added } \frac{(\text{ft.}^3)}{(\text{day})} = \text{Vx } (0.21 - \text{y}).$$

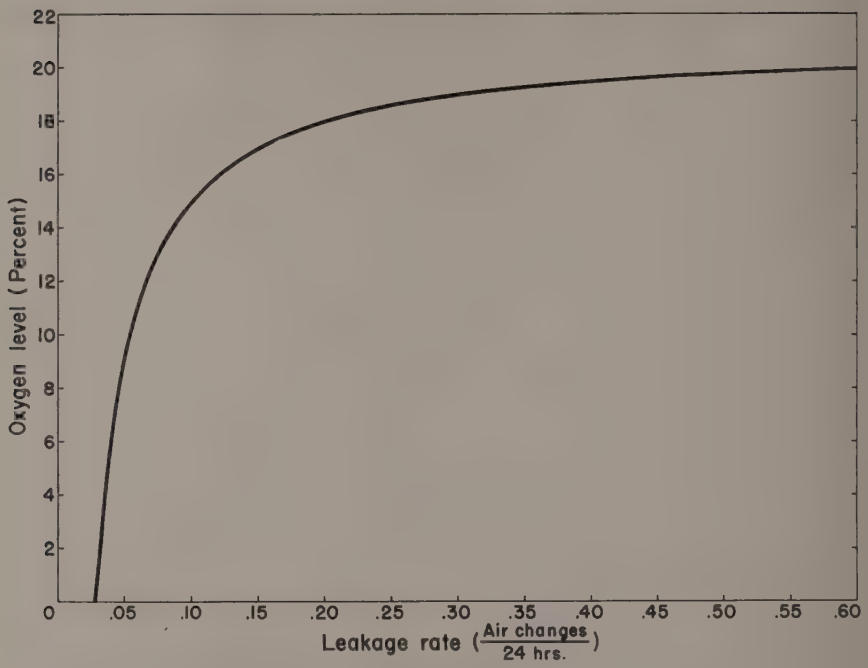

Fig. 1. The relationship of equilibrium oxygen level and leakage rate for a Type 1 CA storage with a space factor of 2.5 and a respiration rate of 0.015.

Again the oxygen added must equal the oxygen consumed:

$$Br = Vx\ (0.21 - y) + (rB - Vxc)\ 0.21, \text{ and}$$

$$y = 0.21\ (1 - c) - \frac{0.79\ r}{xz} \quad \text{(equation 2)}$$

In Figs. 2 and 3, equation 2 is used to relate the equilibrium oxygen level with the rate of leakage for space factors and respiration rates that may be met in commercial CA storages. Both equations 1 and 2 are of the form of a hyperbola. By rearrangement, equation 1 shows that the reduction in oxygen level varies inversely with the leakage rate; the same is true in equation 2 for low carbon dioxide concentrations.

The effect of temperature on the behavior of the CA storage is to alter the rate of respiration. As Fig. 4 shows, a reduction in storage

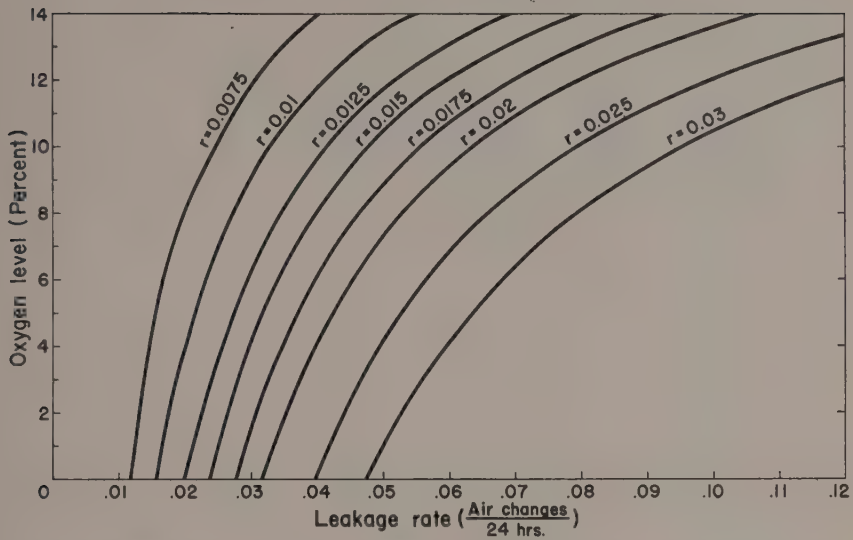

Fig. 2. The relationship of equilibrium oxygen level and leakage rate for a range of respiration rates in a Type 2 CA storage with a space factor of 2.5 and a carbon dioxide level of 0.05.

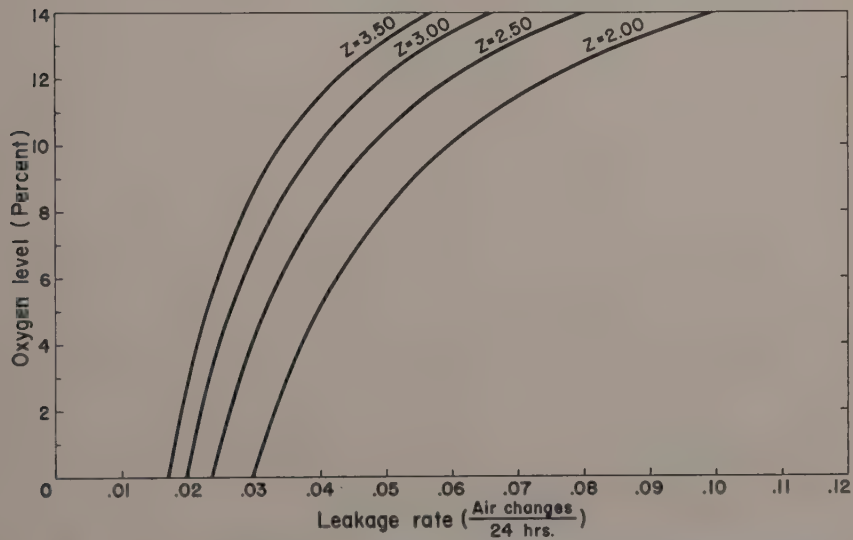

Fig. 3. The relationship of equilibrium oxygen level and leakage rate for a range of space factors in a Type 2 CA storage with a respiration rate of 0.015 and a carbon dioxide level of 0.05.

temperature from 42° to 38° F. reduces the rate of respiration (assuming a Q_{10} of 3 and a respiration rate of 0.017 at 40° F.) from 0.019 to 0.015 and reduces permissible leakage from 0.041 to 0.031 air changes per day.

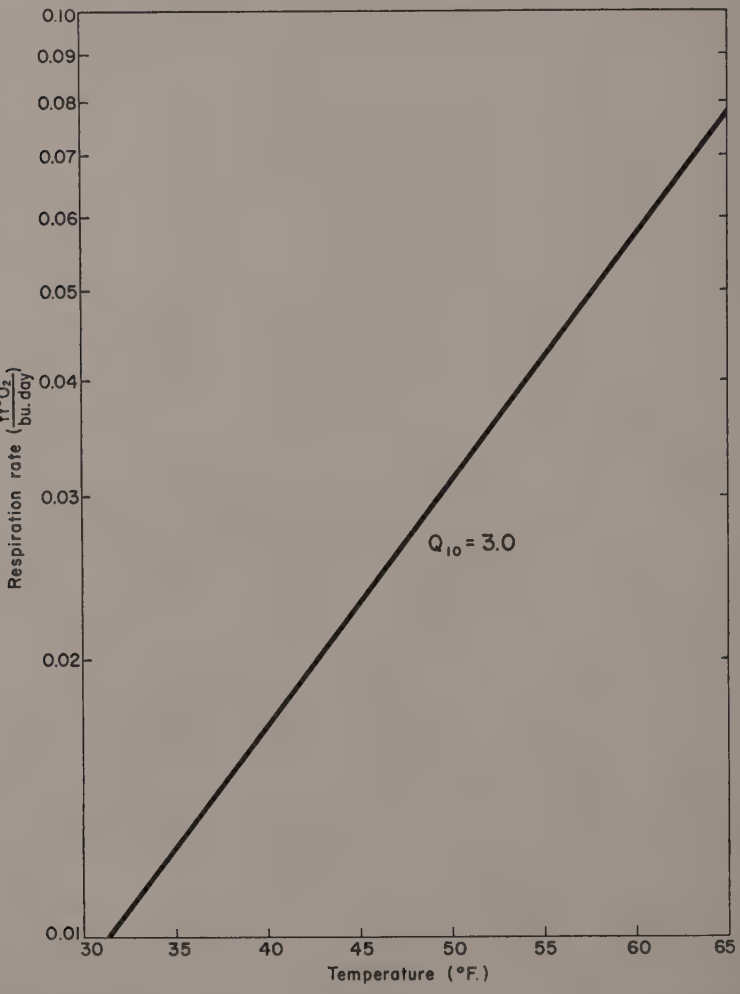

Fig. 4. The effect of temperature on the respiration of apples, assuming a respiration rate of 0.017 at 40°F. and a Q_{10} of 3.

SUMMARY

An equation has been derived to relate air leakage, respiration rate, room fullness, and equilibrium oxygen level for a controlled atmosphere storage room containing respiring fruit. The effects of the variables are illustrated graphically. It is believed that these relationships will aid in explaining the effects of temperature, small changes in room tightness, and degree of room fullness on the operation of the CA fruit storage.

SOLAR HOUSING FOR SWINE

By J. S. BOYD and J. A. HOEFER[1]

DEPARTMENTS OF AGRICULTURAL ENGINEERING AND ANIMAL HUSBANDRY

RESEARCH HAS SHOWN that good housing for pigs results in faster gains and feed savings up to 10 percent compared with results obtained in poor surroundings.

The housing environment of pigs can be improved in several ways. One of these methods involves the use of energy from the sun: a solar hog house. This principle, long used in dwelling design, has certain advantages when used for swine housing. Solar housing provides a hog house with a dry floor and well-lighted surroundings: conditions favorable for hog production in Michigan.

In conventional hog housing, 1 square foot of glass is normally recommended for each 20 square feet of floor area. Not only is this a relatively small amount of glass, but, in this type of housing, conventional windows become frosted in winter; dirt and dust collecting on the glass reduce the effectiveness (Fig. 1). In winter, when light is necessary and desirable, the frost usually allows little sunlight to enter; consequently, no sun heat is available.

With the development of insulated glass, heat loss through the windows can be reduced. It is then possible to use more window area, making more wintertime sun heat available to keep the hog house warm. The higher ventilation rate will remove more vapor in the air. This sun heat helps provide a dry, warm bed in the pen: a condition needed for good pork production.

PRINCIPLE OF OPERATION

The solar principle is based on the use of insulation, ventilation, and the sun as a source of wintertime heat. The light rays of the sun come through the glass in a short wave length. They are converted

[1]Acknowledgment is made to S. M. Ruffin, E. A. Kazarian, and M. Brandt whose research contributed to this study.

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Fig. 1. Two identical houses with the same number of pigs in each. The house with no frost (right) has insulated glass windows; the frosted house has regular glass.

into longer wave heat rays when they strike the bedding, the floor, or other surfaces (Fig. 2). The longer wave heat rays do not escape as readily through double pane glass as through single glass due to the higher insulating value.

In addition to window insulation, adequate insulation should

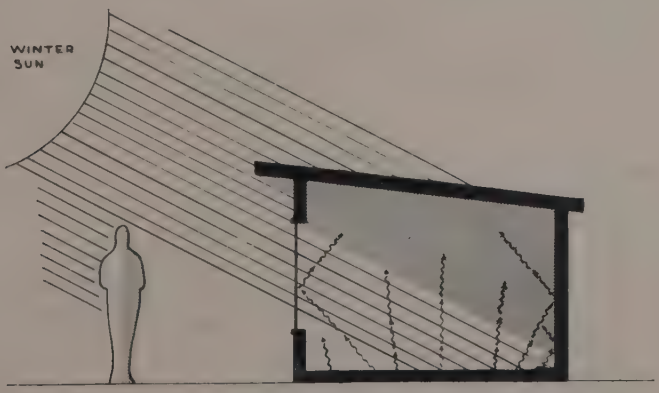

Fig. 2. Sun enters building as short wave lengths. It is converted to long heat waves and trapped.

be placed in the walls and ceiling to prevent heat loss through the rest of the building. As there is more heat available, ventilation must be provided to remove the moisture and excessive heat.

ORIENTATION

To use the sun's heat, windows should face south or east. Southern orientation lets the sun enter the building from morning until night during the winter months when extra warmth is needed for moisture removal and a more comfortable temperature. In the summer, the building can and should be shaded from the hot sun.

The ridge on conventional type buildings usually runs north and south. This lets too much sun enter during the summer, creating too much heat for efficient pork production. In the winter, the sun is to the south, and very few direct rays enter through east and west windows.

A solar building is oriented with the long axis running east and west; windows are placed on the south side. On the north side, windows are held to a minimum or eliminated entirely to reduce the amount of exposed glass and wall area (Fig. 3).

In the winter, increasing the amount of heat entering the building will make up for heat losses. This extra heat also permits a higher ventilating rate. In the summer, high temperatures can be prevented

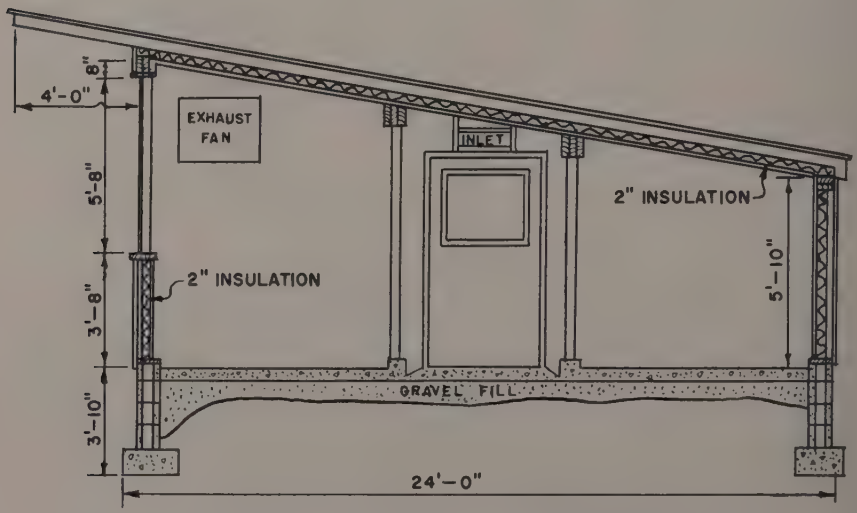

Fig. 3. A typical cross section of a solar-oriented hog house.

by keeping out as much sun as possible. A shading device over the windows facing south will shut out the direct rays of the sun from late spring through early fall (Fig. 4). The winter sun is low enough to shine beneath the shade, exposing the entire window area to the heat from the sun.

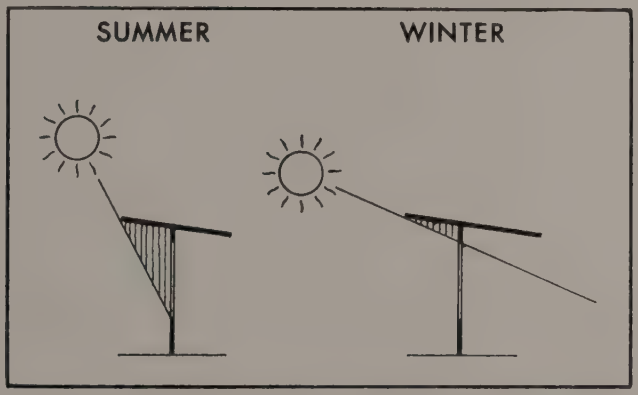

Fig. 4. Shades are designed to allow sun to enter the building in winter and to keep it out in the summer.

VENTILATION

With the increase in the amount of available heat in the house, higher ventilating rates should be used. A rate of 25 cubic feet per minute (c.f.m.) per adult hog will give adequate ventilation during the spring and fall season. During the winter, some method of control, preferably a thermostat, should shut off the fan before the temperature drops to an uncomfortable point or to freezing.

During the summer when outside temperatures approach the inside temperature, additional air should be circulated through the house. Large doors, as wide as 6 to 8 feet, in the east and west ends of the building can be opened to allow natural cross ventilation. Under most conditions, with the doors open on either end, fans will not be needed.

If fans are necessary in the summer, an opening near the ceiling will remove the warm air when the temperature outside begins to rise. Removal of air near the ceiling tends to maintain lower temperatures in the building. The ducts can extend vertically through

the roof, or the fans can be located in the sidewall with ducts extending down along the outside wall.

For wintertime ventilation, the fans should be located in a duct which extends within 36 to 42 inches of the floor. This allows the moist, cold air next to the floor to be removed first.

INSULATION

The better the structure is insulated, the better the control of conditions, both winter and summer. To maintain a nearly uniform temperature, insulation must be provided in the walls and ceiling. (Fig. 3 shows a cross section of a typical solar hog house design.) It is recommended that 2 inches of blanket-type insulation or its equivalent be installed where frame construction is used for the walls and ceiling. The cores of lightweight masonry blocks can be filled with granulated insulation to increase the insulation value.

Insulation in the sidewalls also prevents condensation on the walls. A vapor barrier should be used on the roomside surface of the insulation to prevent moisture from accumulating in the walls; this prevents the sills and studs from rotting.

The insulating windows consist of two thicknesses of glass with a sealed dehydrated airspace between. For farm buildings, these units come either in 1/8-inch double strength window glass with a quarter-inch airspace for small windows, or 3/16-inch sheet glass with a half-inch airspace for the larger windows. This insulating airspace reduces heat transfer through the glass. The windows should be set flush with the inside wall to further lessen condensation or frosting of the glass. With increased insulation in the window area, the accumulation of moisture and frost can be markedly reduced.

WORKING CONDITIONS

Another feature of a solar hog house is that winter working conditions are better. Most workers prefer the solar hog house over the conventional style. Dry floors reduce the amount of bedding required, the number of changes in bedding, and the labor of bedding and cleaning.

Before constructing a solar building, the design should be checked by an engineer familiar with solar principles to be sure the dimensions are correct. This may determine the success or failure of a building planned to take advantage of the solar principle of heat.

Fig. 5. In winter, the sun is low and throws a pattern over the entire floor.

Complete plans for a solar-designed hog house are available from the agricultural engineering department, Michigan State University, East Lansing, Michigan. Farm Building Series Circular 730 also is helpful in determining window sizes and the length of the roof overhang to shade the windows from the summer sun.

JOURNAL ARTICLE ABSTRACTS

Flow Sheets of Prepackaged Fresh Meats

VOEGELI, M. M.; L. J. BRATZLER AND W. L. MALLMANN

Food Tech. 7: 350-352. 1953. (Journal Article 1390 from the Michigan Agricultural Experiment Station)

Microbial counts were made of the environmental surfaces of a retail meat packaging unit. Counts were also made on prepackaged beef, lamb, and pork after periods of display in a self-service meat case.

The meats were cut, packaged and stored at 34° to 38°F. in self-service cases in cooperating markets for 5 days. The packages were sampled every 24 hours; pour plates were made and incubated for 72 hours at 68°F.

Environmental surfaces, such as trays, walls, knives, etc. were sampled by swabbing. Pour plates were made and incubated at 68°F. for 120 hours.

The results indicated that meat cutting equipment used in the packaging operation offered the greatest source of contamination. Increase in numbers of micro-organisms during the first 3 days of display was small. Thereafter, a rapid increase was found.

Factors Affecting Crop Response to Sodium, Applied as Common Salt on Michigan Muck Soil

HARMER, P. M.; E. J. BENNE, W. M. LAUGHLIN AND CORNELIA KAY

Soil Sci. 76: 1-18. 1953. (Journal Article 1459 from the Michigan Agricultural Experiment Station)

A variety of crops grown on organic soils in Michigan were fertilized. In some instances, fertilizers contained sodium compounds; in others, similar fertilizers were used without sodium compounds.

Data are given to show the effects of these treatments on the yields and composition of the crops. Composition of the fertilizer, composition and drainage of the soil, variety of the crop, and seasonal climate were factors determining the amount of response to sodium-responsive crops. Response to sodium applications was likely to be greater in a wet season than in a dry one if the drainage was good.

Crops were divided into four groups on the basis of their response to sodium: (1) little or no response, even with insufficient potash supply; (2) slight to medium response with insufficient potash supply; (3) slight to medium response with ample potash supply; and (4) large response with ample potash supply.

Utilization of Phosphorus by Sugar Beets as Affected by Fertilized Placement

LAWTON, K.; A. E. ERICKSON AND L. S. ROBERTSON

Agronomy Jour. 46: 262-267. 1954. (Journal Article 1483 from the Michigan Agricultural Experiment Station)

A field experiment was conducted to determine the effect of fertilizer placement on the yield and fertilizer phosphorus uptake by sugar beets. A complete mixed fertilizer containing ammoniated superphosphate tagged with P^{32} was ap-

plied to a Brookston clay loam soil by three placement methods, including banding, drilling, and sidedressing.

In the first 2 months of growth, sugar beet tops and roots obtained the highest percentage of fertilizer phosphorus from fertilizer applied in a band below and to the side of the seed. With increased lateral growth of roots in July and August, the uptake of fertilizer phosphorus was highest in beet tops and roots from plots receiving fertilizer in 7-inch drill rows. Phosphate fertilizer sidedressed along sugar beet rows about 2 months after planting was rapidly absorbed by the beet plant. One month after the sidedressed application, fertilizer phosphorus constituted about 40 percent of the total plant phosphorus.

Significant yield response was obtained from phosphate fertilizer with all methods of placement. Although higher average yields were obtained from split application placements, the data indicate that yield differences between single and split application fertilizer placements were not statistically significant.

Cobalt Investigations on Some Nova Scotia Soils

WRIGHT, J. R., AND K. LAWTON

Soil Sci. 77: 95-105. 1954. (Journal Article 1485 from the Michigan Agricultural Experiment Station)

Greenhouse and laboratory studies were conducted on 14 Nova Scotia soils to determine their cobalt status and the influence of dolomitic limestone and cobalt on the yield and cobalt content of oats and timothy. The effects of gypsum, copper, and varied rates of nitrogen, phosphorus, potassium, dolomite, and cobalt on the yield and cobalt content of timothy grown on Woodville sandy loam were also studied.

The soils ranged in texture from sandy loam to clay. Cobalt content varied from 3.6 to 21.0 p.p.m. The cobalt content of the soils was significantly correlated with texture and cation-exchange capacity but not with organic matter content, pH, percentage base saturation, or exchangeable calcium or magnesium.

There was a significant relationship between the cobalt content of the oat plants and soil pH and texture but not with cation-exchange capacity or organic matter content. There was no correlation between the cobalt content of the soils and that of the oat and timothy crops grown on them.

In general, soil applications of cobalt did not significantly affect the yield of oats and timothy. Soil applications of cobalt sulfate heptahydrate at 2 pounds an acre resulted in a threefold average increase in the cobalt content of the oat crop.

Dolomite caused a significant decrease in the uptake of native soil cobalt by the oat plants. The plant uptake of cobalt applied to the soil was markedly reduced by the application of dolomitic limestone.

Varying the rate of application of nitrogen, phosphorus, and potassium had no effect on the cobalt content of timothy grown on Woodville sandy loam.

Copper sulfate applied to the Woodville soil at the rate of 20 pounds an acre significantly depressed the yield of timothy; where dolomite was not applied, copper sulfate significantly increased the cobalt content of the plants. Timothy yields on the Woodville soil were not affected by 2 tons per acre applications of gypsum. The cobalt content of the plants was markedly increased by such treatment, regardless of whether cobalt was applied.

Increasing the pH of the Woodville soil from 5.2 to 6.1 reduced the uptake of cobalt by timothy, but a further increase in pH from 6.1 to 7.0 had no significant effect on the cobalt content of the crop.

Improving Egg Quality Through R.O.P. Breeders—A Progress Report

DAWSON, L. E.; L. R. CHAMPION, J. A. DAVIDSON AND H. C. ZINDEL

Poultry Sci. 33: 293-297. 1954. (Journal Article 1494 from the Michigan Agricultural Experiment Station)

In May 1951, a sample of eggs (one egg from each layer) was obtained from each of 10 R.O.P. breeders. These eggs (1,620) were broken-out in the laboratory and the albumen quality, shell quality, and incidence of spots were determined.

The average percentage of thick albumen varied among flocks from 52.4 percent to 66.8 percent. Shell thickness ranged from an average of .0121 inch to an average of .0143 inch. Percentage of eggs with spots varied from 5.52 percent in one flock to 66.7 percent in another. Greatest variation among breeds was found in percentage of eggs with spots. Leghorn eggs had the lowest incidence of spots, while R.I. Red eggs had the highest incidence. Least variation among the breeds and strains studied occurred in shell thickness.

In April and May 1952, 1,632 eggs from 407 hens (four Leghorn flocks, three White Rock flocks and two R.I. Red flocks) were obtained for quality observations. Egg quality differences among individual hens were observed. The egg quality data obtained for each hen were used as one criterion in the selection of breeders for the 1952-53 breeding season.

The quality of eggs from the pullets produced from these matings will be measured. The families which produce eggs of superior quality will be maintained for breeders.

This method of research with existing commercial strains of poultry should result in improvement of the general level of egg quality on a large number of farms.

Use of Pituitary Material in Propagation of Minnows

BALL, R. C., AND E. H. BACON

Progressive Fish-Culturist 16: 108-113. 1954. (Journal Article 1610 from the Michigan Agricultural Experiment Station)

The use of carp pituitary in the propagation of the creek chub (Semotolos atromaculatus), a minnow important to the live bait industry, has enabled assured production and supplies of this fish.

Viable eggs and normal fry can be obtained by this method about 6 weeks before the normal spawning season. This is very important in getting the fish to salable size during the short period of greatest demand.

Effect of Forced Exercise on Bull Fertility

SNYDER, J. W., AND N. P. RALSTON

Jour. Dairy Sci. 38: 125-130. 1955. (Journal Article 1616 from the Michigan Agricultural Experiment Station)

One group of dairy bulls (eight Holsteins and eight Guernseys) were forced-exercised on a mechanical exerciser daily, except Sundays, for 6 months. At the same time, a comparable group received no exercise other than movement in their stalls. Each of these groups was divided into high and low fertility subgroups within breeds and assigned at random to treatment groups.

Data from the 853 semen ejaculates (453 from the exercised and 400 from the nonexercised bulls) showed that exercise did not significantly favorably in-

fluence the semen characteristics studied either within or between breeds and either within or between fertility level subgroups.

Breeding records showed that exercise did not significantly favor a higher overall percentage of nonreturns. Exercise did appear to significantly improve the percentage nonreturns in high fertility Guernsey sires.

Libido was not significantly affected by exercise. The appetites and general well-being of the exercised bulls were not markedly affected.

Lethal Effects of Electrons on Insects which Infest Wheat, Flour, and Beans. II.

BAKER, V. H.; O. TABOADA AND D. E. WIANT

Ag. Engr. 35: 407-410. 1954. (Journal Article 1617 from the Michigan Agricultural Experiment Station)

Information on the effects of accelerated electrons on insects which infest wheat, flour, and beans is presented along with information on the method used to calculate dosage, penetration of electrons into wheat and flour, rate of treatment of product, cost of electrical energy for a given dose in rep, distribution of current density, calculation of the temperature rise in a given sample, and a review of literature on the effects of accelerated electrons on vitamins and enzymes.

The use of accelerated electrons to stop adult insects from reproducing and to sterilize insect eggs in wheat, flour and beans offers promise for insect control; however, this process is still in the experimental state.

A Method for the Collection of Large Quantities of Rat Saliva

BENARDE, M. A.; S. ROSEN, F. W. FABIAN, C. A. HOPPERT AND H. R. HUNT

Jour. Dental Res. 35: 326-327. 1956. (Journal Article 1657 from the Michigan Agricultural Experiment Station)

A method for the collection of rat saliva is described. The animals were first anesthetized with Nembutal. This was followed by subcutaneous injection of pilocarpine. The animals were then placed in a holder until sufficient quantities of saliva were obtained. About 2 to 5 ml. of saliva could be collected from an adult rat within 20 minutes with about 10 percent mortality.

A Nest of *Heriades variolosus* (Cress.); (Hymenoptera: Megachilidae)

FISCHER, R. L.

Canadian Entomologist 87: 33-36. 1955. (Journal Article 1673 from the Michigan Agricultural Experiment Station)

The nest of *Heriades (Neotrypetes) variolosus variolosus* (Cresson), one of the megachilid bees, is described for the first time. The nest consists of a series of cells arranged in a linear fashion to conform with the tubular hole, one above the other, in a hollowed-out stem of sumac, *Rhus glabra*. Five cells make up the nest. Separating the cells are intercellular partitions composed of resis and soil particles brought in from the outside by the bee.

Distinctive features of the nest are described. These include the cap support which is apparently a salivary secretion of the mother bee and is used for supporting each of the caps and partitions between the cells, and the helter skelter arrangement of the faeces pellets about the outside of the pupa case.

Various views of the nest are given in pictures. The phylogenetic implications of this type of nest construction as compared with *Hoplitis* (the nearest relative of *Heriades* whose biology is known) are also discussed.

Mineral Supplement "Iodine X" and Breeding Hen Performance

LIBBY, D. A.; K. Y. LEE AND P. J. SCHAIBLE

Feedstuffs 26: 35-36. 1954. (Journal Article 1685 from the Michigan Agricultural Experiment Station)

Six White Plymouth Rock hens were fed an all-mash breeder ration and then the same mash for 4 weeks with 4.4 percent "Iodine X", prepared in Japan by the low-temperature carbonization of brown seaweed. The product analyzed 7.82 percent water, 0.66 percent iodine, 14.29 percent potassium and 10.0 percent salt; the remainder was mainly carbon.

Droppings from the hens were greenish-black, but no diarrhea developed. Egg production and hatchability decreased. There were no changes in eggshell thickness, egg weight or day-old chick weight. Two-week weights of hatched chicks from hens on the supplemented ration were not as great as the controls. The preliminary test did not indicate beneficial effects on hen or chick performance.

The Life Cycle of *Isospora Felis* in the Kitten

HITCHOCK, D. J.

Jour. Parasitology 41: 383-397. 1955. (Journal Article 1704 from the Michigan Agricultural Experiment Station)

The life history of this parasite consists of two asexual cycles and one sexual cycle. The first asexual phase, described for the first time, existed from the second to the fourth days. The second asexual phase lasted during the fifth and sixth days, and the sexual cycle remained during the seventh and eighth days.

Since oocysts were passed on the seventh and eighth days, this presents a prepatent period different from that previously thought to exist.

All parasitic stages of *I. felis* found were intracellular in the surface epithelial cells of the intestine, as formerly reported.

Most of the sexual and asexual stages were found in the small intestine, but a few sexual stages were found in the cecum. A few asexual forms were present in the cecum and, for the first time, noted in the large intestine.

The majority of the mature second generation schizonts contained 12, 14, or 16 merozoites.

No pathological conditions or symptoms attributed to this infection were noted.

A Study of the Growth-Promoting Effects of Trimethylalkylammonium Stearate and Antibiotics for Pigs

LUECKE, R. W.; J. A. HOEFER AND F. THORP, JR.

Jour. Animal Sci. 15: 765-769. 1956. (Journal Article 1758 from the Michigan Agricultural Experiment Station)

In three separate trials involving a total of 145 pigs, the addition of trimethylalkylammonium stearate to the ration increased average daily gains over the

unsupplemented control groups. However, in only two of the trials was this growth stimulation found to be statistically significant.

Supplementary levels of 50 grams per ton of feed were found to be most effective, and levels of 400 grams per ton of feed had no harmful effects. The mechanism by which this compound exerts its growth-promoting effect is unknown.

Studies on the Preservation of *Leptospira icterohemorrhagiae* by Freezing

SHIGEKAWA, J. M., AND J. J. STOCKTON

Am. Jour. Vet. Res. 16: 619-622. 1955. (Journal Article 1763 from the Michigan Agricultural Experiment Station)

Viability of *Leptospira icterohemorrhagiae* grown in Korthoff's medium, concentrated by centrifugation, suspended in various colloidal substances, and stored at subzero temperatures, has been demonstrated for periods up to 1 year.

Leptospiras survived for at least 8 months when suspended in skim milk or in normal horse serum and stored in a dry ice chest. When suspended in 1 percent starch, 3 percent gelatin, 2 percent casein, and skim milk, and stored at −27°C.; viability has been demonstrated for 9 to 12 months. When suspended in 3 percent gelatin, 1 and 2 percent casein, skim milk, normal horse serum and egg yolk, and stored at a temperature of −47°C.; survival has been demonstrated for 1 year.

Blood and Tissue Partition of Cobalt 60 in Dogs

LEE, CHENG-CHUN, AND L. F. WOLTERINK

Am. Jour. Physiology 183: 173-177. 1955. (Journal Article 1771 from the Michigan Agricultural Experiment Station)

Within 12 hours after intravenous injection of inorganic Co^{60} into the dog, blood cells contain an insignificant amount of Co^{60}. About 72 to 75 percent of the whole blood Co^{60} is precipitable with cadmium hydroxide and remains 'non-diffusible' on dialysis. Co^{60}, as $Co^{60}SO_4$, is both readily absorbed from the intestine and 'secreted' or 'continuously diffused' into the intestinal tract through its wall in the dog.

High concentrations of Co^{60} are found in the liver, in the intestinal tract, in the kidney, in the gall bladder bile, and in the bladder urine. The spleen contains a low amount of Co^{60}.

Reabsorption of Cobalt 60 from Urine and Bile Samples of Experimental Dogs

LEE, CHENG-CHUN, AND L. F. WOLTERINK

Science 123: 65. 1956. (Journal Article 1772 from the Michigan Agricultural Experiment Station)

A form (or forms) of Co^{60} other than its inorganic form was found in the bile and in the urine samples that were collected from experimental dogs. The Co^{60} in these samples is reabsorbed from the gut of young chicks at a considerably faster rate than inorganic Co^{60} is absorbed.

Utilization of Radioisotopes in Resolving the Effectiveness of Foliar Absorption of Plant Nutrients

TUKEY, H. B.; S. H. WITTWER, F. G. TEUBNER AND W. G. LONG

Proc. Intn'l. Conf. Peaceful Uses of Atomic Energy, V12 Radioactive Isotopes and Ionizing Radiations in Agriculture, Physiology and Biochemistry. August 1955. pp. 137-143. (Journal Article 1776 from the Michigan Agricultural Experiment Station)

Although roots are usually considered the principle site for absorption of mineral nutrients, it has been shown that the same nutrients are readily absorbed when sprayed up the leaves. Certain elements, like radiophosphorus or potassium, are absorbed very rapidly and move freely in the plant; while calcium and iron are absorbed and transported very slowly and, usually, only upward.

Results show that the rate and efficiency of phosphate uptake is much faster and higher from leaves than by the roots from sandy, loamy, or organic soils. The rate of uptake, transport, and accumulation are affected by the chemical nature of the treating solution, time of application, method, temperature, nutrient level, and various other factors.

In addition, nutrients were found to be lost from the foilage during rainfall. This loss was dependent upon physiological factors, including nutrient level, rate and duration of rainfall, plant species, and others.

Studies of Cortisone-Vitamin Interactions

MEITES, J.; Y.S.L. FENG AND A. M. WILWERTH

Proc. Bk., Am. Vet. Med. Assoc. Ninety-second annual meet.: 136-143. 1955. (Journal Article 1782 from the Michigan Agricultural Experiment Station)

Large doses of cortisone acetate were injected into young male rats fed a ration deficient in vitamin B_{12}, thiamine, or pyridoxine. That their condition was aggravated was shown by an increased loss of body weight, reduction in hair growth, and decrease in thymus weight.

A reduction in food intake was not responsible for the catabolic actions of cortisone, since these rats actually ate more on a body weight basis than rats not treated with cortisone. It was evident, therefore, that large doses of cortisone induced food wastage in these rats. When the intake of vitamin B_{12}, thiamine, or pyridoxine was increased five to ten times above the amounts usually required for normal growth by young rats, the ability of large doses of cortisone to reduce body and hair growth and thymus weight was partially or largely counteracted.

It was evident, however, that the doses of cortisone used also partially interferred with the normal growth effects of these vitamins in young rats. Biochemical assays revealed that when large doses of cortisone were injected into vitamin B_{12}-deficient rats, there was a pronounced hyperglycemia and glucosuria (cortisone diabetes), and greatly increased quantities of nitrogen were excreted into the urine. There was also a marked interference with the ability of insulin to increase sugar utilization.

An increased intake of vitamin B_{12} greatly reduced the hyperglycemia, glucosuria, and urinary nitrogen losses and tripled the ability of insulin to reduce blood sugar levels. The increased effectiveness of insulin in the presence of an abundant intake of vitamin B_{12} (and presumably of other B vitamins) is believed to account for the beneficial effects of the vitamin in rats given large doses of cortisone.

The Influence of Certain Sugars on the Antifungal Activity of Sodium Pyridinethione

RINGEL, S. M., AND E. S. BENEKE

Mycologia 48: 329-336. 1956. (Journal Article 1793 from the Michigan Agricultural Experiment Station)

The modification of medium constituents was effective in altering the antifungal activity of the sodium salt of 2-pyridinethione. This compound inhibits *Colletotrichum phomoides* C80A at 0.04 μg/ml. in the presence of sucrose, whereas 0.32 μg./ml. are required when three other sugars were used.

Progressive retardation in the growth curves was noted at increasing concentrations of this compound when sub-inhibitory amounts were employed. At sub-inhibitory levels, pyridinethione markedly affects the germ tube development of various fungal spores.

The Isolation of *Listeria monocytogenes* from the Liver of Calves and a Discussion of Intrauterine Infection

GRAY, M.L.; C. A. LASSITER, H. D. WEBSTER, C. F. HUFFMAN AND F. THORP, JR.

Vet. Med. 316-318, 335-336. 1956. (Journal Article 1811 from the Michigan Agricultural Experiment Station)

Listeria monocytogenes was isolated from the livers of six calves ranging in age from 2 to 19 days. The predominant symptoms were general weakness and loss of weight. The most consistent lesions at necropsy were hepatic necrosis and gastroenteritis. Three calves showed various alterations in the heart. Reference also was made to the isolation of *L. monocytogenes* from the heart valves of a 7-day old lamb.

From these and other naturally infected young animals and experimental evidence cited, it was suggested that the role of *L. monocytogenes* in abortion and prenatal death may be of greater importance than previously suspected. The need for maceration and refrigeration of tissues to be cultured for *L. monocytogenes* was stressed.

Report on Molybdenum in Plants

BENNE, E. J. AND D. M. JERRIM

Jour. Assoc. of Off. Agr. Chemists 30: 412-419. 1956. (Journal Article 1813 from the Michigan Agricultural Experiment Station)

Recognition of the importance of molybdenum in plant and animal metabolism resulted in including in the Book of Official Methods of the Association of Official Agricultural Chemists a method for determining the small quantities of this element that occur naturally in plants.

This paper describes the preliminary efforts of the authors to select a suitable method. A review of the literature on the subject is given, together with values for the molybdenum contents of a number of plant materials which were analyzed by a method selected and adapted by the authors.

Dried Whey and Lactose as Supplements to a Vegetable Milk Replacer

NOLLER, C. H.; C. F. HUFFMAN, G. M. WARD AND C. W. DUNCAN

Jour. Dairy Sci. 39: 992-997. 1956. (Journal Article 1832 from the Michigan Agricultural Experiment Station)

Twenty-one Holstein calves were divided into three groups of seven calves each and placed on the following milk-replacer rations: basal, basal plus 5 percent dried whey, and basal plus 3.5 percent lactose at 4 days of age. The calves in the three groups consumed 54.9, 51.9, and 50.7 pounds of whole milk, respectively.

Average daily gains on the three rations were 0.87, 0.92, and 0.87 pound, respectively. The differences were not statistically significant. The calves receiving the whey ration had more costive feces and smoother coats and were more alert. Lactose appeared to have no benefit under the conditions of this experiment.

Comparison of Silages Made From Field Corn (Ohio M15) and Silage Corn (Eureka) for Milk Production

HUFFMAN, C. F., AND C. W. DUNCAN

Jour. Dairy Sci. 39: 998-1005. 1956. (Journal Article 1833 from the Michigan Agricultural Experiment Station)

Immature (Eureka) and mature (Ohio M15) corn crops grown in the same field were ensiled in separate silos at the same time. Just before ensiling, the two varieties were randomized to calculate the yields per acre, dry matter content, yield of stalks, bushels of U. S. No. 2 corn, and pounds of corn and stalks per pound of silage.

The silages were compared in feeding trials with and without a grain supplement. In the trials without grain supplement, there were no significant differences in the amount of fat-corrected milk produced per pound of dry matter. The estimated average amount of U.S. No. 2 corn consumed in the immature silage was 0.76 pound, whereas the mature silage supplied 5.6 pounds per day.

In 12 trials where the immature and mature silages were compared using a grain supplement, the cows produced slightly more milk on the mature corn silage, although the difference was not considered significant.

The Influence of Sealing Pressure on Survival of *Serratis marcescens* and *Micrococcus pyogenes var. aureus* Desiccated from the Frozen State

CHRISTIAN, R. T., AND J. J. STOCKTON

Applied Microb. 4: 88-90. 1956. (Journal Article 1835 from the Michigan Agricultural Experiment Station)

For high percent livability in cultures desiccated from the frozen state, low drying and sealing pressures are important. To obtain a high percent viability, as high a vacuum as possible should be used during the drying process; to maintain this high percent livability, sealing pressures should be as low as possible. At sealing pressures below 100 microns of mercury, the percent viability rises rapidly.

Some Effects of Microwaves on Certain Insects Which Infest Wheat and Flour

BAKER, V. H.; D. E. WIANT AND O. TABOADA

Jour. Econ. Enty. 49: 33-37. 1956. (Journal Article 1849 from the Michigan Agricultural Experiment Station)

Adult flour beetles (Tribolium Confusum Duv.) and adult granary weevils (Sitophilus granarius (L.)) were treated in a Radarange with microwaves of a frequency of 2,450,000,000 cycles per second.

A maximum temperature of 165°F. with an exposure time of 21 seconds was fatal to 100 percent of flour beetles 1 week after treatment; 23 percent of the eggs hatched. Two percent of the eggs hatched when exposed 21 seconds at a temperature of 178°F. A temperature of 187°F. for 18 seconds was fatal to 100 percent of the larvae.

An exposure time of 15 seconds at 172° F. was fatal to 100 percent of adult granary weevils 1 week after treatment. No eggs hatched. Only 2.5 percent of the eggs hatched when exposed at a temperature of 162°F. for 12 seconds.

Separation of Egg White Proteins by Paper Electrophoresis

EVANS, R. J., AND S. L. BANDEMER

Jour. Agr. and Food Chem. 4: 802-810. 1956. (Journal Article 1865 from the Michigan Agricultural Experiment Station)

A procedure was developed for the quantitative determination of the various proteins in egg white by paper electrophoresis. The proteins were separated by the ridgepole technique of Durrum using a pH 8.6 diethylbarbiturate (barbital) buffer of 0.05 ionic strength. A number of buffers between pH 4.3 and 9.1 were tried in a sandwich type horizontal paper electrophoresis cell, and mobilities of the various egg white proteins were determined with them before the barbital buffer was chosen for quantitative use.

The separated proteins were dyed with bromophenol blue, the bands separated by cutting the paper strips, and the protein-bromophenol blue complex eluted from each band with dilute sodium hydroxide solution. The color intensity was determined at 590 millimicrons wavelength in the spectrophotometer, and percentages of the different proteins in egg white were then calculated.

Fresh egg white protein contained 65.2 percent ovalbumin (48.4 percent A_1, 12.6 percent A_2, and 4.2 percent A_3); 11.2 percent ovomucoid plus ovoglobulin, 17.0 percent conalbumin, 2.1 percent nonmobile protein; and 4.5 percent lysozyme.

The Fat-Lean Ratio in the Rough Loin as a Tool in Evaluation of Pork Carcasses

PEARSON, A. M.; L. J. BRATZLER, J. A. HOEFER, J. F. PRICE, W. T. MAGEE AND R. J. DEANS

Jour. Animal Sci. 15: 896-901. 1956. (Journal Article 1866 from the Michigan Agricultural Experiment Station)

The fat-lean ratio is an index of the area of fat in proportion to the area of lean in cross section of the rough loin at the last rib. Details of the method of circumscribing the areas to be measured are given.

Results with 102 hog carcasses indicate that the fat-lean ratio may be a

useful measure of leanness when cut-out data cannot be obtained. However, the area of lean at the tenth or last rib was only slightly less reliable than the fat-lean ratio for predicting cut-out values.

Considering the relationship between either carcass length or dressing percentage and carcass cut-out, it appears that major emphasis in carcass evaluation should be placed on other methods of measuring leanness.

The Mysteries of the Rumen

HUFFMAN, C. F.

Jour. Dairy Sci. 39: 688-692. 1956. (Journal Article 1872 from the Michigan Agricultural Experiment Station)

Due to the increased scientific investigations in this area, the mysteries surrounding the rumen of dairy cattle are less numerous than before.

The rumen and reticulum make up one large compartment (commonly referred to as the Fermentation Vat) where an enormous number of microbes (bacteria and protozoa) live. The microbes are responsible for the digestion of celluloses, hemicelluloses and related compounds for the cow. They also make high quality protein and vitamins of the B complex for their host.

Short-chained fatty acids are byproducts of microbial fermentation. These are absorbed through the rumen wall into the body where they are used for energy. One of these acids is acetic, which is needed for the making of a certain amount of fat by the mammary gland.

The gases, methane, and carbon dioxide are other byproducts of fermentation and represent lost energy. Under certain conditions, elimination of these gases is interfered with, resulting in bloat.

Seed Vernalization and Flowering in Lettuce *(Lactuca sativa)*

RAPPAPORT, L.; S. H. WITTWER AND H. B. TUKEY

Nature 178: 51. 1956. (Journal Article 1873 from the Michigan Agricultural Experiment Station)

Many conflicting reports have appeared as to the effectiveness of seed vernalization in hastening flowering in lettuce. Therefore, a standard procedure for vernalization of lettuce was developed. This procedure consisted of pregerminating moist seed at 60 to 70°F. for 24 to 48 hours and then subjecting it to 40°F. for at least 13 days. Leaf numbers and number of days before the appearance of the developing inflorescence and anthesis in Great Lakes head lettuce were used. It was found that night temperatures above 65°F. following seed vernalization hastened flowering and resulted in seedstalks without prior head formation.

At temperatures below 65°F., vernalized plants first produced a high percentage of firm, vegetative heads and then flowered. Nonvernalized plants flowered only at night temperatures above 65°F. At high root temperatures (64 and 71°F.) flowering was promoted; while at low temperatures (50 and 57°), flowering was delayed. Following vernalization, the lowest night temperature at which early flowering was favored was reduced from 65 to 60°F. when plants were grown at a daylength of 16 hours. With a 9-hour photoperiod, regardless of vernalization, plants produced firm heads which eventually flowered.

A combination of high air and root temperatures and long days appears to promote flowering in seedlings vernalized over 13 days at 40°F.

Abortion and Pre- or Postnatal Death of Young Due to Listeria Monocytogenes. III. Studies in Ruminants

GRAY, M. L.; CHINTAMANI SINGH AND FRANK THORP, JR.

Am. Jour. Vet. Res. 17: 510-516. 1956. (Journal Article 1875 from the Michigan Agricultural Experiment Station)

Listeria monocytogenes added to the drinking water of two pregnant ewes and three pregnant goats produced fatal listeric infection in the young. This resulted in abortion if exposure was early in gestation, or by death of the young within the first postnatal week if exposure was near term. Two dams died from listeric septicemia after exposure. One pregnant goat was infected by contact with the exposed goats and aborted fetuses.

Lesions in the fetuses and the young born at term appeared to be identical to those seen in natural outbreaks of listeric abortion or prenatal death. Of 57 isolations of *L. monocytogenes* from fetuses and membranes, seven were positive only after refrigeration of the tissue suspensions. A goat exposed by conjunctival instillation late in gestation died of listeric encephalitis. Three normal young were delivered by caesarian section.

Listeric abortion may be a public health hazard.

Report of a Nutritional Survey of the Residents of a County Hospital and Infirmary and Patients Assigned to a Rehabilitation Section of a Second County Hospital

BREWER, W. D.; M. E. FURNIVALL, A. WAGONER, J. LEE, B. ALSOP AND M. A. OHLSON

Jour. Am. Diet. Assoc. 32: 810-815. 1956. (Journal Article 1902 from the Michigan Agricultural Experiment Station)

Blood hemoglobin and blood serum concentrations of ascorbic acid, vitamin A, and carotene were determined for residents of two county hospitals in Michigan. Information was obtained about the dietary habits of residents of the two institutions.

The nutritional status of the two groups appeared to be better in relation to vitamin A than ascorbic acid. However, less than 10 percent of the residents of the two hospitals could be considered in poor nutrition with respect to both vitamin A and ascorbic acid.

Mean values for blood hemoglobin, ascorbic acid, vitamin A, and carotene of men and women of Institution A were higher than those of patients in Institution B. Likewise, the quality of food preparation and the acceptance of food were better in the first institution. The management of this institution had received and used the advice of a competent state nutritionist.

There was greater variability in hemoglobin and serum vitamin A concentrations in the blood of persons in the sixth through the eighth decades than among the younger people. This variability could measure an exaggeration of the accepted variabilities of any population sample, and it could be associated with aging and the various infirmities of age found among the individuals of the sample. A more probable explanation would be differences in acceptance or rejection of certain foods by this age group.

Agronomic Use of an X-ray Induced Mutant

DOWN, E. E., AND A. L. ANDERSEN

Science 124: 223-224. 1956. (Journal Article 1908 from the Michigan Agricultural Experiment Station)

In 1940, an early bush mutant segregated from a lot of Michelite bean seed treated with X-ray in 1938. This mutant was increased in size by backcrossing to Michelite followed by selection. The recovered mutant was used in a cooperative bean breeding program begun in 1948, between the Michigan Agricultural Experiment Station and the U.S. Department of Agriculture. This research program has resulted in the introduction of the variety Sanilac, a bush type, to Michigan agriculture.

The Sanilac variety is superior to Michelite in earliness (6 days), in resistance to Alpha strain of bean anthracnose fungus, and in holding its pods off the ground at harvest. It is less liable to injury from white mold disease of beans. The Sanilac variety is similar to Michelite in seed type, canning quality, and resistance to common bean mosaic.

Causes and Control of Root Rot in Michigan Greenhouses

SCHEFFER, R. P., AND W. J. HANEY

Plant Disease Reporter 40: 570-579. 1956. (Journal Article 1910 from the Michigan Agricultural Experiment Station)

The pathogens most often isolated from Croft lily, poinsettia, and other plants with root rot were *Rhizoctonia solani* and *Pythium ultimum.* The latter fungus from Croft lilies was pathogenic to *Lilium pumilum* seedlings, *L. longiflorum* var. Georgia, poinsettia, sweet pea, and several other plants. Pythium from poinsettia appeared to be identical with Pythium from Croft lily.

Evidence indicates that both *R. solani* and *Pythium spp.* are introduced into greenhouses with fieldgrown bulbs. Many bulb and soil treatments were tried without success on Croft lilies. No chemical treatments were as satisfactory as soil steaming for poinsettia production.

Seed germination assays showed that PCNB controlled *R. solani* and had good residual properties, but that it was without effect on *P. ultimum.* Captan used as a soil mixture at high concentrations inhibited both fungi, but it had poor residual properties. Certain pyridinethione derivatives were effective and were fairly stable in the soil.

Weed Control in a Row

LILJEDAHL, J. B.; W. M. CARLETON AND D. M. KINCH

Agr. Engr. 37: 550-552, 554. 1956. (Journal Article 1911 from the Michigan Agricultural Experiment Station)

Control of weeds in the row is a problem in sugar beet production. Work reported here was directed toward possible methods of sterilizing weed seeds in a strip of soil in which the sugar beet seeds were to be planted. Three methods were investigated: (1) Ultrasonic energy, (2) heat energy by conduction, and (3) mechanical energy.

Results were: (1) Ultrasonic energy could sterilize seeds but the effect was almost entirely that of heating; (2) heat energy to sterilize a strip of soil ¾-inch

deep by 4 inches wide was considered excessive as about 7 to 10 gallons of fuel oil would be needed per acre; and (3) a centrifugal device to mechanically sterilize soil was constructed.

The treatment gave significant results in sterilization of weed seeds under certain tests, but the investigators finally decided that the treatment was of insufficient merit to warrant further development.

Fungicide and Insecticide Seed Treatments of Peas and Beans

deZEEUW, D. J.; G. E. GUYER AND A. L. ANDERSEN

Plant Disease Reporter 40: 727-733. 1956. (Journal Article 1917 from the Michigan Agricultural Experiment Station)

Three years' testing of seed treatment fungicides, insecticides, and combinations on Round Pod Kidney Wax beans at East Lansing, Michigan, and on Alderman peas at East Lansing and Jackson, Michigan, is reported.

Seventy-six treatments, including commercial preparations, at various rates and laboratory mixtures of fungicides and insecticides were used in one or more of the trials. Most materials containing the fungicides captan, thiram, and dichlone gave good results on both peas and beans. The mercury compounds generally gave less consistent protection.

One experimental material, Ethyl B-856, was outstanding in pea trials and was as effective as the established captan and thiram fungicides. In spite of the apparent low incidence of seed-corn maggot in the experimental plots, insecticides generally benefited beans. Insecticides were usually slightly harmful to peas, whether used alone or in combination with fungicides.

The differences concerning insecticides in stands were usually less than the difference needed for statistical significance, but they were considered consistent enough to indicate biological significance.

Effects of Variants in Pipeline Installations on the Acid Degree of Fat in Milk

JOKAY, L., AND J. M. JENSEN

Milk Plant Monthly 45: 23, 24, 25, 30. 1956. (Journal Article 1936 from the Michigan Agricultural Experiment Station)

Farm pipeline installations, with and without risers and of varying lengths, were observed for their contribution to rancidity in milk as measured by acid degree values, surface tension, and taste. The acid degree was determined by the solvent extraction procedure.

Results support previous studies that have shown rancidity to be initiated principally by conditions that cause foaming of milk when fat is in the liquid state.

Acid degree values in milk increased with increase in length of line and increase in number and height of risers. Foaming due to leaky milk valves was a major contribution to high acid degree values. Churning occurred to a serious extent in long milk lines with numerous risers. Acid degree values of high order in milk were brought into normal range by reducing the number and height of risers, the length of lines, and, especially, the air inlet.

A relationship is shown between taste, surface tension, and acid degree values.

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